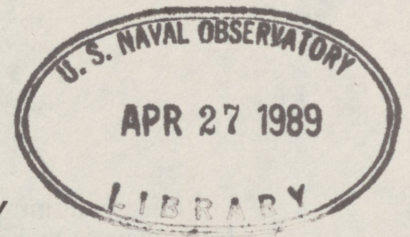


OB
4
U33



UNITED STATES NAVAL OBSERVATORY

CIRCULAR NO. 173

U. S. Naval Observatory, Washington, DC 20392

December 15, 1988

Total Solar Eclipse of 22 July 1990

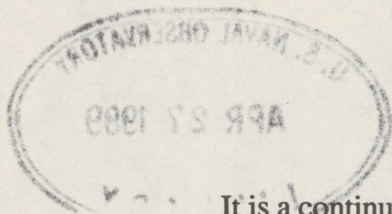
by

Alan D. Fiala

John A. Bangert

and

William T. Harris



The U. S. Naval Observatory Eclipse Circulars

It is a continuing policy of the Nautical Almanac Office to prepare issues of the series of U. S. Naval Observatory *Circulars* containing detailed information for observing most total solar eclipses and some annular solar eclipses. This is a service to the international scientific community, based on agreements with Commissions and Working Groups of the International Astronomical Union.

The target date for distribution is 18 months in advance of the eclipse date. As a regular publication of the U. S. Naval Observatory, distribution is made to institutions with which the Observatory has exchange agreements or other obligation. *No other mailing list, request file, or subscription service is maintained. Users must make a new written request for each eclipse Circular approximately 18-20 months prior to the event.* There is no charge for a single copy. Please address requests to:

Eclipse Circulars
U. S. Naval Observatory
Washington, DC 20392-5100

The content and layout of the eclipse *Circulars* is continually being reviewed and revised. Users' comments are solicited, on useful features to be continued as well as suggestions for changes or additions.

It is permissible to reproduce any portion of this *Circular*, except for any material noted as having been published elsewhere or prepared by someone who is not a staff member of the U. S. Naval Observatory. It is requested that when any information herein is used for any purpose, that an appropriate acknowledgement of the source be made.

*Next Eclipse Circular: Total Solar Eclipse of 11 July 1991
Available: early 1990*

CONTENTS

General Information and Explanation of Contents	4
Overall Eclipse Map, from the <i>Astronomical Almanac for 1990</i>	8
Surface Path of the Total Phase, tabulated by Universal Time (UT)	9
Elements of the Eclipse	10
General Circumstances of the Eclipse	10
Besselian Elements	
Polynomial Form	10
Tabular Form, tabulated by UT	11
Weather Prospects, by Jay Anderson	12
Sky Maps for Joensuu, Finland and Atka, Alaska, USA	17
Local Circumstances	
For Points on the Central Line, tabulated by UT	18
For Geographic Locations (total and partial phases)	20
Limb Corrections	
Explanation	24
Correction Diagrams for Joensuu, Finland, by David Herald	25
Lunar Limb Profile Diagram	26
Surface Path of the Total Phase Over Land, tabulated by longitude	27
Path of the Central Line at Flying Altitudes, tabulated by UT	32
Corrections to UT and Latitude for Elevations Above Sea Level	34
Detail Maps of Portions of the Path Over Land	
Finland	36
Finland/USSR Border Region	37
Taymyr Peninsula (USSR)	38
Cherskiy, USSR	39
Markovo, USSR	40
Aleutian Islands (Alaska, USA)	41
Legend	42

GENERAL INFORMATION

A total eclipse of the Sun will occur on Sunday, 22 July 1990. It will be followed by an associated partial eclipse of the Moon on Monday, 6 August. The duration of totality will be slightly longer than 2 1/2 minutes at maximum. This eclipse belongs to saros series number 126. The last preceding eclipse in this series was the total solar eclipse of 10 July 1972; the next eclipse in the series will be the total solar eclipse of 1 August 2008.

The last preceding total solar eclipse occurred on 17-18 March 1988 over Indonesia and the Philippines. Since then, annular solar eclipses have occurred on 11 September 1988 over the Indian Ocean and on 26 January 1990 over Antarctica. Partial solar eclipses occurred on 7 March 1989 over western North America and on 31 August 1989 over southeastern Africa and Antarctica. The next total solar eclipse will be the long eclipse of 11 July 1991 over Hawaii, Mexico, Central America, and South America.

PATH AND VISIBILITY

Inexperienced observers are cautioned to observe only by use of projected images, and not to use any method which would cause them to look directly at the Sun.

At approximately 1h 53m UT on 22 July 1990, the center of the umbra of the Moon's shadow will touch the Earth at sunrise at a point in the Gulf of Finland. The path will be approximately 171 km wide and the duration of totality will be approximately 1m 27s. Approximately 30 seconds later, the center line will have reached the border with the Soviet Union. During its passage over southeastern Finland, the Moon's umbral shadow will cover the capital city of Helsinki and numerous smaller towns easily accessible by bus, rail, or air. Unfortunately, the Sun's altitude as seen from these locations will remain below 6° throughout the total phase of the eclipse. Continuing its northeastward journey through the Soviet Union, the path will cross the White Sea. The center line will reach the eastern Kola Peninsula where it will intersect the Arctic circle at approximately 1h 56m UT. The track will continue over the Barents Sea with the center line reaching the southern end of the island Novaya Zemlya at approximately 2h 01m UT. By this time, the path width will have grown to approximately 189 km and the duration of totality will be approximately 1m 55s. The track will then cross the Kara Sea, reaching its northernmost point over the tundra of the Taymyr Peninsula at approximately 2h 19m UT. The path will then proceed southeastward, crossing the Laptev Sea and the Magadanskaya region of the extreme eastern Soviet Union. The maximum duration of totality (2m 36s) occurs over this region, as does the maximum altitude of the Sun during total eclipse (approximately 40°). The track will leave the Asian continent at approximately 3h 11m UT, when the path will be approximately 208 km wide and totality on the center line will last approximately 2m 35s. Twenty-four minutes later, the path will have crossed the Bering Sea and reached the Aleutian Islands, passing over the larger islands of Atka, Adak, Seguam, and Amukta. The path width will have grown to 214 km with totality on the center line lasting approximately 2m 24s.

The center of the Moon's umbral shadow will leave the Earth at sunset at 4h 11m UT over the North Pacific Ocean, west of California. Because the track will cross the International Date Line, by local times the eclipse will begin on the morning of Sunday, 22 July over Finland and end on the evening of Saturday, 21 July over the Pacific Ocean.

Partial phases of the eclipse, of magnitude decreasing with the distance from the path of the total phase, will be visible over northern Greenland, northeastern Scandinavia, the arctic regions, the Soviet Union, northern China, most of Japan, northwestern North America, and many Pacific Island groups including the Hawaiian Islands.

SKY AT MAXIMUM TOTALITY

Diagrams of the sky as it will appear at maximum eclipse from two locations near the limits of the path over land are given elsewhere in this *Circular*. Centered on the zenith for each of the two locations, the diagrams show planets and stars brighter than magnitude 2.0. At the time of the eclipse, the Sun and Moon will be in Cancer, close to the border with Gemini. As seen from Finland, maximum eclipse will occur shortly after sunrise; thus, the Sun and Moon will be very low in the northeastern sky. Jupiter, just one week past conjunction, will shine at magnitude -1.8 approximately 7° to the south of the eclipsed Sun. Castor and Pollux will be the bright pair approximately 10° to the southwest. Brilliant Venus (-3.9) will be present in the eastern sky approximately 18° above the horizon. Mars will be in the southeastern sky at magnitude +0.1 while the "summer triangle" of Vega, Deneb, and Altair will dominate the western sky. As seen from the Aleutian Islands, maximum eclipse will occur with the Sun and Moon in the western sky. Jupiter and Venus will lie to the northwest of the eclipsed Sun while Mercury (-0.4) will shine approximately 19° to the southeast. Castor and Pollux will now lie to the north. Vega and Deneb will be the bright stars in the northeastern sky; Arcturus and Spica will be the bright stars in the southeastern sky.

CHANGE IN CONTENTS

Due to the inaccessibility of portions of the central path, some of the detailed path maps have been omitted. Detailed maps are provided for the central path over Finland, the western Soviet Union bordering Finland, the Taymyr Peninsula, part of the Magadanskaya region of the eastern Soviet Union, and the Aleutian Islands. Additionally, the scale of the maps has been enlarged (see below) and, at the beginning of the central path, the dashed time lines are given at 30 second intervals instead of the usual 1 minute intervals. The table giving the central path as a function of longitude at flying altitudes has been replaced by a table providing the path of the central line at flying altitudes as a function of time. In the table of local circumstances for geographic locations, the altitude of the Sun at maximum eclipse and the times of second contact, maximum eclipse, and third contact have all been corrected for the effects of refraction, assuming standard conditions. Only one set of limb correction diagrams (for Finland) is provided.

PARAMETERS AND CORRECTIONS

The predictions in this *Circular* are derived from the solar and lunar data contained in the DE200/LE200 ephemeris developed jointly by the Jet Propulsion Laboratory and the U. S. Naval Observatory for use in the *Astronomical Almanac* for 1984 and after. In order to best take into account the rough limb of the Moon, the value of $k = 0.2725076$ for the ratio of the radius of the lunar profile to the Earth's radius is used throughout the calculations. The International Astronomical Union (IAU) adopted the new value for k in August 1982. Along with that value, corrections have been applied to both lunar latitude and longitude to help account for the difference between the center of figure and the center of motion (see Elements of the Eclipse). It is expected that the observer will then make the final limb corrections, as described elsewhere in this *Circular*. As usual, all time arguments are in Universal Time (UT), using the best value of ΔT [the difference between Terrestrial Dynamical Time (TDT) and UT] available at the time of preparation (see Elements of the Eclipse). The convention of longitude positive east is used throughout this *Circular*.

DETAILED PATH MAPS

The detailed maps provided in this *Circular* are presented on portions of the Defense Mapping Agency's Operational Navigation Charts (ONC), scale 1:1,000,000, Lambert Conformal Conic Projection. The portions in this *Circular* are reduced to 50% of original size, enlarging the scale from 15.78 miles/inch to 31.56 miles/inch. For an explanation of the maps, see *Estimating Second and Third Contacts* below.

LOCAL CIRCUMSTANCES

DEFINITIONS. *First and fourth contacts* are, respectively, the beginning and the end of the partial phase. *Second and third contacts* are, respectively, the beginning and end of the total phase, if it occurs at the given location. *Duration* is the time interval between second and third contacts. Dot leaders indicate that a phenomenon occurs below the horizon for a given location.

The *position angle* of a point of contact on the solar limb is measured eastward (counterclockwise) around the solar limb. P is the position angle measured from the north point on the limb; V is the position angle measured from the vertex point. The *north point* lies on the great circle arc drawn from the north celestial pole to the center of the solar disk; the *vertex point* lies on the great circle arc drawn from the zenith to the center of the solar disk. If the angle is listed as negative, add 360° .

The *azimuth* of the Sun is measured along the horizon clockwise from the north point eastward to the foot of the great circle arc drawn from the zenith through the center of the solar disk down to the horizon. If it is listed as negative, either add 360° or measure westward from north.

The *magnitude* of the eclipse is the fraction of the apparent diameter of the solar disk covered by the Moon at the time of greatest phase, expressed in units of the solar diameter.

Degree of *obscuration*, computed especially for this *Circular*, is the fraction (per cent) of the area of the apparent solar disk obscured by the Moon at maximum eclipse.

TABLES. In addition to the table of local circumstances on the center line, a table of accurate local circumstances for a list of selected geographic locations is provided. The locations were chosen for their position near the central path, general geographic distribution, and size of population. Coordinates were taken from *The Times Atlas* or read from the detailed maps in this *Circular*. All coordinates are approximate and assumed to be sea level. The printed circumstances correspond to the printed coordinates, in case there should be an error in identification or coordinates. It is often difficult in preparing maps and local circumstances to ascertain the correct name and spelling for a given location. *Therefore, the information presented here is for location purposes only; it is not authoritative, and does not imply recognition of the status of any area by the United States government.* The altitude of the Sun at maximum eclipse and the times of second contact, maximum eclipse, and third contact given in this table have been corrected for the effects of atmospheric refraction, under the assumption of standard conditions.

For the user who wishes to calculate local circumstances, the elements of conjunction, general circumstances, and Besselian Elements for UT arguments are provided. The Besselian Elements are given as usual in tabular form, and also in polynomial form. Precepts for the calculations of local circumstances can be found in the Explanation of the *American Ephemeris and Nautical Almanac* for 1980 or earlier years.

ESTIMATING FIRST AND FOURTH CONTACTS.

Beginning and end of the partial phase, or first and last contacts, can be estimated using the one-page overall map reproduced in this *Circular* from the *Astronomical Almanac*. The dashed lines show the surface outline of the Moon's penumbra at a time interval of 30 minutes. The short dashes show the leading edge, the long dashes show the trailing edge. First contact occurs when the leading edge passes over the location in question, last contact occurs when the trailing edge passes. Duration is the time difference between contacts. The time halfway between is the middle of the eclipse. This is near the time of maximum eclipse, but not necessarily identical. At a given location, one need only estimate the intermediate position of the penumbra's edge between the starting and ending lines on either side and thus the time of the contact. For observers within the elongated "tear-drop" curves to the extreme east and west, part of the eclipse occurs below the horizon.

ESTIMATING SECOND AND THIRD CONTACTS.

Low precision times of second and third contacts in the central path can also be estimated. The central path over land is shown on a series of detailed maps in this *Circular*. Elsewhere in the *Circular* is a table of Local Circumstances for Points on the Central Line. On the maps, the heavy solid lines mark the northern and southern limits of the predicted path. Each dashed line represents the projection of the diameter of the umbra, joining the northern and southern limits and central point for the indicated instant, at which all points on the dashed line experience maximum eclipse. Use the maps and table as follows: Find on the maps the location in the path for which you want local circumstances. From the one-minute cross lines on either side, estimate or measure the time t_0 when the projected axis line of the umbra will pass over the point. Turn to the table of Local

Circumstances for Points on the Central Line. Find where the time t_0 fits into the first column on each page. Using the appropriate fraction of the time interval, read across both pages and interpolate the times of second and third contacts, the duration (D), and the width of the path (a). Make a note of the angles P and V for each contact (for use as described in the next section), and also the altitude (a) and the azimuth (A) of the Sun at maximum eclipse. Turn back to the map. If you mark the cross lines for the second and third contact times, you can see the breadth of the projected shadow. Now draw a line through the observing point perpendicular to the path. Estimate or measure how far the point is from the center of the path and call this quantity b (a and b must be in the same units). Next compute the approximate duration (T) for the selected location by:

$$T = D\sqrt{1 - (2b/a)^2}$$

Then, the time of second contact is approximately $t_0 - T/2$, third contact $t_0 + T/2$.

ESTIMATING POSITION ANGLES. The lunar limb profile for this eclipse is provided elsewhere in this *Circular*. For locations in the central path, the predicted times and position angles of contacts are based on the Moon's mean limb (the smooth circle). Correction for limb irregularities is discussed later. In working with this construction, remember that the position angles are given for the solar disk, which is observable, but corrections are based on features on the lunar disk, shown in the diagram. The two nearly coincide between second and third contacts, so it is adequate to plot angles pertaining to the Sun on the lunar diagram. However, this is not the case for first and fourth contacts. You may find it convenient to use a transparent overlay with a circle of radius three inches.

For each second or third contact to be sketched for a location given in a table, take from the table the time of contact (t_c), the angles P and V , and the altitude (a) and the azimuth (A) of the Sun at maximum eclipse, as described above. Convert the time of contact to hours and decimals. The topocentric position angle of the lunar axis (C) is a function of time, the position of the Moon and the Sun, and the location of the observer. For this eclipse, compute C from the following equation:

$$C = 9^\circ.83 + 0^\circ.193 t_c - 0^\circ.37 \cos a \sin (P - V).$$

On the diagram, N marks lunar north. Using the four direction tick marks, find the center of the circle. Draw a line from the center through N . Next measure the angle C westward (clockwise) from N . Mark the point on the mean limb and draw a line from the center through it. This points to the Earth's north celestial pole. From this line, measure back the angle P eastward (counterclockwise) to find the point of contact on the mean limb. Draw a line from the center out through that point. Finally, from that line, measure through the angle V westward (clockwise). Draw a line from the center through this point. This line points to the observer's zenith. Now you can visualize events as follows: Facing in the direction of the Sun's azimuth (A), measured in degrees positively from the north point of the horizon around clockwise to the east, hold the diagram up at

arm's length at the altitude (a) of the Sun at maximum eclipse, and turn it so that the line pointing to the zenith points straight up. The line to the north point of the disk will point to celestial north for the observing site, and the point of contact at the limb will be at its correct apparent orientation.

To get position angles for locations not listed in the tables, follow the directions given above for estimating second and third contacts, and plot the points of second and third contacts for the interpolated (P, V) on the center line. Draw a line connecting the two contacts on the mean limb. It should pass through the center of the disk in approximately an east/west direction. In order to transfer this line of motion to a parallel one for a point off the center line, draw or construct a perpendicular diameter, which runs approximately north/south. Taking $(2b/a)$ from the calculation of duration, measure off $(2b/a) \times \text{radius}$ from the center of the circle along the north/south diameter in the same direction as the observing site is from the center line. Mark the point on the diameter, and draw or construct perpendicular to it, another line parallel to the line through the central line contact points. This new line will intersect the mean limb at approximately the points of contact. The eastern point is for second contact, the western is for third contact. This construction is not as accurate as a full calculation, but adequate for field estimates.

OBSERVATIONS

Precise observations of the second and third contact times, at any part of the path, but especially the northern and southern limits, are needed and requested. Since precise coordinates of the observer must be determined, reports of such timings should indicate location information, such as nearest settlement, roads to the site, distance to nearby landmarks or identifiable buildings and the nearest road intersection, distance from the center of the road, etc. The method of timing also should be described. Precision requirements are to within 0.5 seconds of time and 50 feet in location. Please send reports to:

Nautical Almanac Office
U. S. Naval Observatory
Washington, DC 20392-5100 USA

Inexperienced observers are cautioned to observe only by use of projected images, and not to use any method which would cause them to look directly at the Sun.

Information on photography, direct viewing, and projection methods may be found in the following publications:

- "Safe Solar Filters," by B. Ralph Chou, *Sky and Telescope*, August 1981, p. 119.
- "Observing the Sun in Safety," by J. C. D. Marsh, *J. Brit. Astron. Assoc.*, 1982, 92, 6, p. 237.
- Astrophotography Basics*, Kodak Customer Service Pamphlet AC-48, 1981.
- A Complete Manual of Amateur Astronomy*, by P. Clay Sherrod, Prentice-Hall, 1981.
- Eclipse*, by Bryan Brewer, 1979.
- Observe: Eclipses*, by R. Sweetsir and M. Reynolds, Astronomical League, 1979.

FURTHER INFORMATION

For information concerning eclipse activities in Finland, contact:

Reino Anttila
Helsinki Observatory
Tahtitorninmaki
SF-00130 Helsinki FINLAND

The Astronomical Council, USSR Academy of Science, has under the Solar Section, a Working Group on Solar Eclipses to coordinate all activities. The Chairman is:

Dr. Edward Kononovitch
Sternberg State Astronomical Institute
Universitetskij Prospect 13
Moscow B-234 USSR

Inquiries concerning special calculation of local circumstances and extensions or modifications of data in this publication should be directed to the Nautical Almanac Office at the address given in the previous section.

ACKNOWLEDGEMENTS

The weather prospects section was contributed by meteorologist Jay Anderson of the Pacific Weather Centre, Vancouver, B.C., Canada.

The charts to correct contact times for the effects of lunar limb features were contributed by David Herald, Woden, A.C.T., Australia.

The detailed maps are presented on portions of the Defense Mapping Agency's (DMA) Operational Navigation Charts (ONC) B-3, C-2, C-3, C-7, D-3, D-9, and E-12. Information concerning availability, purchase prices, and ordering instructions can be obtained by calling DMA at 1-800-826-0342 from anywhere in the continental United States, (301) 227-2495 from elsewhere, or writing:

Director
Defense Mapping Agency CSC
ATTN: DOA
Washington, DC 20315-0010 USA

The lunar limb profile chart was prepared using software subroutines from the occultation program of the Nautical Almanac Office.

The following specific contributions were made by members of the Nautical Almanac Office staff:

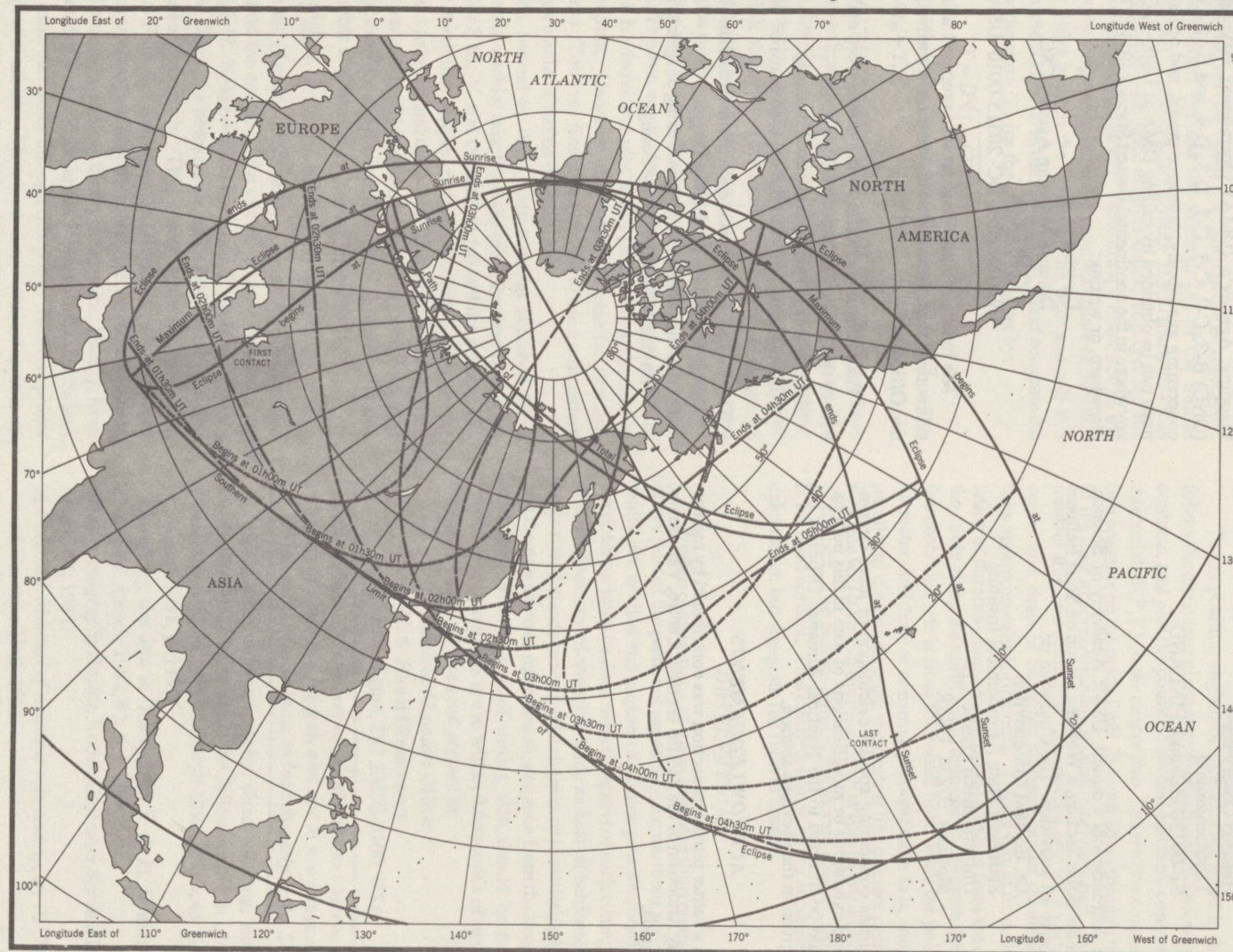
Marie Lukac prepared the overall line map.

William Harris prepared the detailed maps of the path over land.

The polynomial representation of the Besselian elements was programmed by Dr. LeRoy Doggett.

The sky diagrams were prepared using programs provided by Tim Carroll and James DeYoung.

TOTAL SOLAR ECLIPSE OF 1990 JULY 22



SURFACE PATH OF THE TOTAL PHASE

U.T.	Northern Limit		Central Line		Southern Limit	
	Latitude	Longitude	Latitude	Longitude	Latitude	Longitude
Limits	° ' "	° ' "	° ' "	° ' "	° ' "	° ' "
1 54	+60 15.9	+ 22 29.5	+59 46.6	+ 23 42.0	+59 17.3	+ 24 51.9
1 56	+65 38.6	+ 34 11.8	+66 42.9	+ 39 52.5	+67 22.6	+ 44 58.1
1 58	+68 21.9	+ 41 18.9	+68 52.9	+ 46 18.3	+69 10.8	+ 50 60.0
2 00	+70 18.1	+ 47 19.5	+70 31.7	+ 52 05.3	+70 35.7	+ 56 36.0
2 05	+73 38.4	+ 61 20.0	+73 25.3	+ 65 51.6	+73 06.3	+ 70 03.7
2 10	+75 42.4	+ 75 37.6	+75 11.1	+ 79 45.4	+74 35.9	+ 83 27.8
2 15	+76 50.4	+ 90 28.6	+76 05.5	+ 93 49.1	+75 18.8	+ 96 43.3
2 20	+77 10.7	+105 09.9	+76 17.2	+107 24.6	+75 23.2	+109 18.7
2 25	+76 51.7	+118 41.9	+75 54.0	+119 47.8	+74 56.7	+120 42.5
2 30	+76 02.6	+130 24.7	+75 04.3	+130 32.9	+74 06.7	+130 38.2
2 35	+74 52.1	+140 10.2	+73 55.5	+139 36.6	+72 59.5	+139 05.6
2 40	+73 27.1	+148 11.0	+72 33.4	+147 10.0	+71 40.0	+146 14.1
2 45	+71 52.5	+154 46.7	+71 02.2	+153 28.6	+70 11.9	+152 16.7
2 50	+70 11.5	+160 16.0	+69 24.6	+158 47.9	+68 37.6	+157 26.0
2 55	+68 26.0	+164 54.4	+67 42.6	+163 20.8	+66 58.9	+161 53.1
3 00	+66 37.3	+168 54.1	+65 57.2	+167 17.8	+65 16.7	+165 46.9
3 05	+64 46.1	+172 24.4	+64 09.2	+170 47.1	+63 31.7	+169 14.7
3 10	+62 52.8	+175 32.4	+62 18.9	+173 55.2	+61 44.4	+172 22.3
3 15	+60 57.5	+178 23.8	+60 26.5	+176 47.3	+59 54.8	+175 14.5
3 20	+59 00.2	-178 56.8	+58 32.0	+179 27.6	+58 03.0	+177 55.3
3 25	+57 00.6	-176 25.5	+56 35.1	-178 00.2	+56 08.8	-179 31.9
3 30	+54 58.3	-173 58.9	+54 35.5	-175 32.8	+54 11.8	-177 03.9
3 35	+52 52.7	-171 33.6	+52 32.7	-173 06.9	+52 11.7	-174 37.7
3 40	+50 43.0	-169 06.0	+50 25.9	-170 39.2	+50 07.7	-172 10.0
3 45	+48 27.9	-166 32.0	+48 13.9	-168 05.7	+47 58.7	-169 37.1
3 50	+46 05.5	-163 45.8	+45 55.1	-165 21.2	+45 43.2	-166 54.2
3 55	+43 32.7	-160 38.9	+43 26.5	-162 17.9	+43 18.7	-163 54.1
4 00	+40 43.2	-156 55.3	+40 43.0	-158 41.9	+40 40.6	-160 24.6
4 02	+39 28.0	-155 08.6	+39 31.2	-157 00.5	+39 31.6	-158 47.7
4 04	+38 06.1	-153 05.7	+38 13.7	-155 05.7	+38 18.0	-156 59.3
4 06	+36 33.7	-150 37.2	+36 48.1	-152 50.8	+36 57.7	-154 54.6
4 08	+34 41.9	-147 19.9	+35 09.0	-150 01.7	+35 27.1	-152 24.1
4 10	+31 36.9	-140 55.5	+32 58.8	-145 53.4	+33 37.4	-149 04.2
4 12	.. ..	.. ..	.. ..	.. ..	+30 35.5	-142 35.1
Limits	+30 32.8	-138 18.8	+29 56.5	-138 52.5	+29 20.5	-139 25.4

For duration, path width, and altitude and azimuth of the Sun,
please see page 18; Local Circumstances for Points on the Central Line

ELEMENTS OF THE ECLIPSE

U.T. of geocentric conjunction in right ascension July 22^d 02^h 36^m 44^s.998

Julian Date = 2448094.6088541481

	h	m	s		s	s
R.A. of Sun and Moon	8	04	47.193	Hourly motions	9.969	and 146.792
ΔT			56.972			
	°	'	"		'	"
Declination of Sun	+20	21	00.70	Hourly motion	-	0 29.53
Declination of Moon	+21	08	12.41	Hourly motion	-	10 32.24
Equatorial hor. par. of Sun			8.66	True semidiameter of Sun		15 44.5
Equatorial hor. par. of Moon	59	24.74		True semidiameter of Moon		16 11.4
Lunar figure offset, long.	+		0.51			
Lunar figure offset, lat.	-		0.28			

CIRCUMSTANCES OF THE ECLIPSE

	U.T.	Longitude	Latitude
	d h m	° '	° '
Eclipse begins	July 22 0 40.0	+ 60 59.7	+ 43 28.2
Central eclipse begins	22 1 53.4	+ 23 42.0	+ 59 46.6
Central eclipse at local apparent noon	22 2 36.7	+ 142 24.8	+ 73 28.0
Central eclipse ends	22 4 11.2	- 138 52.5	+ 29 56.5
Eclipse ends	22 5 24.5	- 165 15.6	+ 11 22.8

Longitudes are measured positive East.

BESSELIAN ELEMENTS, POLYNOMIAL FORM

The equations below represent simple least-squares fits to the tabular Besselian Elements.

Let $t =$ U.T. in hours defined from 0^h U.T. on 22 July 1990. These equations are valid over the range $0^{\text{h}}.633 \leq t \leq 5^{\text{h}}.575$. Do not use t outside the given range, and do not omit any terms in the series.

$$\begin{aligned}
 x &= -1.40663058 + 0.53846172 t + 0.00000678 t^2 - 0.00000823 t^3 \\
 y &= 1.23706906 - 0.16822912 t - 0.00019130 t^2 + 0.00000278 t^3 \\
 \sin d &= 0.34805862 - 0.00012723 t - 0.00000006 t^2 \\
 \cos d &= 0.93747277 + 0.00004726 t \\
 \mu &= 178.39642295 + 15.00090287 t + 0.00000235 t^2 - 0.00000006 t^3 \\
 \text{Radius penumbra} &= 0.53838186 + 0.00017752 t - 0.00001197 t^2 \\
 \text{Radius umbra} &= -0.00796391 + 0.00017687 t - 0.00001200 t^2 + 0.00000001 t^3
 \end{aligned}$$

BESSELIAN ELEMENTS

U.T.	Intersection of Axis of Shadow with Fundamental Plane		Direction of Axis of Shadow			Radius of Shadow on Fundamental Plane	
	x	y	sin d	cos d	μ	Penumbra	Umbra
h m					$^{\circ}$		
0 00	-1.406630	+1.237069	+0.348059	0.937473	178.39642	0.538382	-0.007964
10	1.316887	1.209026	.348037	.937481	180.89657	.538411	.007935
20	1.227143	1.180972	.348016	.937489	183.39672	.538440	.007906
30	1.137399	1.152907	.347995	.937496	185.89687	.538468	.007878
40	1.047656	1.124832	.347974	.937504	188.39703	.538495	.007851
50	0.957913	1.096747	.347953	.937512	190.89718	.538521	.007825
1 00	-0.868170	+1.068651	+0.347931	0.937520	193.39733	0.538547	-0.007799
10	0.778429	1.040546	.347910	.937528	195.89748	.538573	.007774
20	0.688689	1.012430	.347889	.937536	198.39763	.538597	.007749
30	0.598951	0.984304	.347868	.937544	200.89778	.538621	.007726
40	0.509214	0.956169	.347846	.937552	203.39793	.538644	.007702
50	0.419479	0.928023	.347825	.937559	205.89809	.538667	.007680
2 00	-0.329746	+0.899868	+0.347804	0.937567	208.39824	0.538689	-0.007658
10	0.240015	0.871703	.347783	.937575	210.89839	.538710	.007637
20	0.150288	0.843528	.347761	.937583	213.39854	.538731	.007616
30	-0.060562	0.815344	.347740	.937591	215.89869	.538751	.007597
40	+0.029160	0.787150	.347719	.937599	218.39885	.538770	.007577
50	0.118878	0.758947	.347698	.937607	220.89900	.538789	.007559
3 00	+0.208593	+0.730735	+0.347676	0.937615	223.39915	0.538807	-0.007541
10	0.298305	0.702514	.347655	.937622	225.89930	.538824	.007524
20	0.388012	0.674283	.347634	.937630	228.39946	.538841	.007507
30	0.477716	0.646043	.347613	.937638	230.89961	.538857	.007491
40	0.567415	0.617794	.347591	.937646	233.39976	.538872	.007476
50	0.657109	0.589536	.347570	.937654	235.89992	.538887	.007462
4 00	+0.746798	+0.561270	+0.347549	0.937662	238.40007	0.538901	-0.007448
10	0.836482	0.532994	.347527	.937670	240.90022	.538914	.007434
20	0.926161	0.504710	.347506	.937678	243.40037	.538927	.007422
30	1.015835	0.476418	.347485	.937686	245.90053	.538939	.007410
40	1.105502	0.448116	.347463	.937694	248.40068	.538950	.007399
50	1.195164	0.419807	.347442	.937701	250.90084	.538961	.007388
5 00	+1.284819	+0.391489	+0.347421	0.937709	253.40099	0.538971	-0.007378
10	1.374468	0.363162	.347400	.937717	255.90114	.538980	.007369
20	1.464110	0.334827	.347378	.937725	258.40130	.538989	.007360
30	1.553745	0.306485	.347357	.937733	260.90145	.538997	.007352
40	1.643373	0.278134	.347336	.937741	263.40160	.539004	.007345
5 50	+1.732994	+0.249775	+0.347314	0.937749	265.90176	0.539011	-0.007338

$$\tan f_1 = 0.004602$$

$$\tan f_2 = 0.004579$$

$$\mu' = 0.261815 \text{ radians per hour}$$

$$d' = -0.000136 \text{ radians per hour}$$

ECLIPSE OVER SIBERIA: WEATHER PROSPECTS FOR 1990

Jay Anderson
 Pacific Weather Centre
 200-1200 West 73rd Avenue
 Vancouver, B.C. Canada V6P 6H9

During July temperatures across central Asia and Siberia are climbing toward their annual peak. Mean sea level pressure charts for the month (figure 1) show an immense low pressure system angling across the continent from Iran to the Bering Sea. The morning portion of the eclipse occurs in a region of weak pressure gradients, south of a small low which lingers over the northern Norwegian coast. It terminates over the eastern Pacific near the center of the Hawaiian sub-tropical high.

The dominant winds which hold sway along the eclipse path are controlled by the surface pressure pattern. Along the Arctic coast of Russia winds blow from the northwest, attracted by the low pressure trough over eastern Siberia. Similarly, on the south side of the trough, winds blow from the south and southeast, carrying moist Pacific air onto the east coast of the continent. Past the Aleutians, winds circulate clockwise around the semi-permanent Hawaiian high, bringing the eclipse to a close in the balmy but moist breezes of the northeast trades.

The broad low pressure system which dominates Asia is created by the heating of the continent during the long summer days. Over the Laptev Sea, Arctic air lingers despite the continuous July sunlight, cooled from below by the permanent ice fields which have retreated only a hundred kilometers offshore. The Arctic front marks the point at which the continental and icy air masses meet, moving back and forth with each passing low pressure disturbance, but seldom venturing for long from the northern Siberian coast. The Pacific polar front, separating warm sub-tropical air from that of more temperate latitudes, stretches eastward from Japan almost to the North American coast.

Migrating low pressure systems, each carrying an extensive mantle of cloud, cross mid and high latitudes at irregular intervals. While such disturbances can be found at any point along the eclipse track, they show a distinct preference for Scandinavia and the northwest Pacific. The Scandinavian lows originate over the waters between Scotland and Iceland, moving eastward across the eclipse track into central Russia. Pacific lows form in the waters off Japan and move northeastward past the Aleutian Islands into the Bering Sea. Less frequently, lows develop and move along the Arctic coast of Siberia, dragging the Arctic front northward as they approach, and pushing it southward on departure.

Weak highs build behind the departing lows as northerly winds drive cooler air southward over the Siberian tundra. Usually cloudy at first, the high pressure systems bring brighter weather after a day or two as the sun's heat gradually dries the lower parts of the atmosphere. While sites under such highs offer the best prospects for seeing the sun, they are most notable for their absence in areas affected by the eclipse: there is a modest peak in the frequency of high pressure centers only over southern Finland.

CLOUD COVER ALONG THE ECLIPSE TRACK

Weather prospects for this eclipse are poor. Much of the track passes over the very cloudy skies of the Soviet Arctic, through frontal zones, and across the major tracks of low pressure systems. Even under the sub-tropical high a zone of persistent low cloudiness brings disappointing prospects. Figure 2 shows four measures of mean cloud cover along the eclipse track. Data for the top two graphs are from surface observations while those for the lower are extracted from satellite pictures. Since weather stations are few and far between at high latitudes, statistics in the central portion of the track on the top graphs reflect the data from a small number of locations. These locations give information only for the land portion of the eclipse.

The surface observations show a mean cloud cover of 60 to 80 percent over most of the track, with completely clear skies less than 10% of the month. The most favourable area seems to be that over the European portion of the track, especially Finland, and is likely related to the slightly higher frequency of high pressure systems in the area.

The lower two graphs also show a relatively high cloud cover, generally 50 to 60%, over the European and Asian portion of the shadow path, and around 80% over the Pacific Ocean. In general satellite observations show lower cloud amounts than those estimated from the ground. This bias is due to the surface observer's tendency to estimate higher cloud amounts toward the horizon because of perspective effects. In areas where the eclipse is low in the sky, say below 15 degrees altitude, the surface-based graphs are more representative of regional cloud amount. At higher altitudes the satellite based measurements provide a more realistic measure of the cloud cover.

Notwithstanding the very low sun angle, the most reasonable area to attempt to view this eclipse would be over Finland or western Russia, if for no other reason than accessibility. Figure 3 is a higher resolution map of cloud cover prospects from the Gulf of Finland to the Kola Peninsula. The map shows the percent frequency of less than 3 tenths cloud cover and more than 5 miles visibility – conditions which would likely allow the eclipse to be seen. The region northeast of Helsinki seems a little more favourable, though the shores of the White Sea (near Belomorsk) would offer a greater solar altitude (8 degrees) in exchange for a 10% penalty in the frequency of nearly clear skies.

WEATHER AT SELECTED LOCATIONS

Table 1 shows some of the meteorological characteristics of selected locations along the eclipse track. Helsinki lies at the beginning of the shadow line, on the shores of the Gulf of Finland. Rebohy, in the USSR just over the border with Finland,

represents an inland site on the more accessible portion of the eclipse track. Arkhangel'sk lies on the shores of the White Sea, while Malyje Karmakuly is situated on the island of Novaya Zemlya in the Soviet Arctic. Markovo, in eastern Siberia, is very close to the point of maximum eclipse. Khatyrka lies on the shores of the Bering Sea. Adak, in the Aleutian Islands, represents the last spot of land crossed by the eclipse before it heads out over the Pacific.

Temperatures, while cool by North American standards, are pleasant for this area and this time of year. The mercury is unlikely to drop below the freezing point at any of the continental locations, and may rise into the lower 30's (about 90F) in the afternoons. Winds are generally light over land and higher over the Arctic and north Pacific oceans.

Over the western portions of the eclipse track the most commonly reported cloud is high level cirrus which is generally thin and covers only about one-third of the sky when present. The bulk of the sky cover in this area is contributed by mid level cloud, which is reported less often than cirrus, but tends to mask 50 to 70% of the sky when present. Low cloud is observed least often, but brings the heaviest cover when it occurs. It is most likely in the early morning hours, close to eclipse time.

Low level stratiform cloud is endemic over the Arctic and north Pacific sections, being reported in 60 to 90% of the observations near eclipse time. It tends to be very heavy, covering nearly 90% of the sky on average. Adak in particular has a very low frequency of clear skies.

Markovo, where the eclipse has its most favourable geometry, is tucked in a flat valley in the East Siberian Mountains, on the Anadyr River. To some extent it is protected from the flow of moist Pacific air by the mountains, but peaks in the area are not particularly high (less than 1000 metres) and only the lowest layers of the atmosphere are affected. Lying close to the mean position of the Arctic front, along a favoured track of low pressure systems, and under a persistent upper level trough, it is unable to profit from its topographic advantage and cloud cover is frequent and heavy.

STRATEGIES FOR COPING WITH ECLIPSE DAY WEATHER

While the cloud cover statistics offer little good news for this eclipse, they do not suggest that it will not be seen at all. Lying in the zone of upper level westerly winds, as does much of North America, northern Europe and Asia is travelled by a series of high and low pressure systems. Each of these systems has its own cloudiness characteristics, and if the right area can be found and reached, the chances of clear skies are greatly enhanced.

Weather forecasts are available with a lead time of 10 days over Europe, with increasing accuracy as the date of the eclipse approaches. Since remote areas will require advance planning to reach, observers will have difficulty in taking advantage of the forecasts even this far ahead. Mobility over Finland and western Russia could allow the selection of a favourable site in a short

time, but the low sun dictates a requirement for very little cloud. Observers should attempt to place themselves in a location which is forecast to be beneath a high pressure system, preferably two or more days after a low has passed. Under such circumstances northwesterly winds over Finland will be descending from the mountains of Sweden and Norway, drying as they cross the eclipse track.

While the long range forecasts will likely provide a reliable indication of the expected weather, there are only limited options available to change sites to avoid clouds, especially since cross-border travel along the eclipse centre line is difficult. Success is most likely if the eclipse party has close contact with a weather centre that receives detailed satellite imagery and can direct the group on short notice. Travel, at least, will not be difficult since the sky never turns dark in the short July night.

One option which would substantially enhance the prospects of success would be to plan for an aerial observation of the eclipse, perhaps with the alternative to remain on the ground on eclipse morning if conditions and forecasts warrant. A low solar altitude is an advantage from an aircraft since it would allow the eclipse to be seen directly out of the windows, providing that the aircraft can climb high enough to escape any clouds.

How high is high enough? No global statistics exist on the height of cloud tops above the surface, but under most circumstances the Earth's cloud is confined to the lowest layer of the atmosphere, the troposphere. The top of the troposphere, called the tropopause, is found at relatively low altitudes in northern climates. An aircraft that can reach 40 thousand feet will be able to climb above more than 95% of the tropopause heights measured at the latitude of Finland (figure 4) and thus above almost any kind of weather. In all likelihood cloud cover would be topped well below this level and such performance characteristics would be generous. Only thunderstorms have the capacity to push moisture into the stratosphere and these are very unlikely during the early morning hours. Weather forecasts at the time should allow for several days advanced planning.

Much the same restrictions apply to flights from Alaska, but at the end of the track, west of California, cloud cover is usually topped at a lower level (below 8000 feet). Thunderstorms are rare over Alaskan waters and unlikely and avoidable in the subtropical Pacific at the end of the track.

SUMMARY

The 1990 total solar eclipse occurs in an area of poor weather prospects and difficult access. Detailed short range meteorological information and a facility for movement are likely to have the most influence on success. Climatology shows that Finland has the lowest frequency of cloud cover but this is more than offset by the low solar altitude of the eclipse.

Aircraft offer the most promising platform from which to view this spectacle, especially near the sunrise and sunset portions of the track. Long range passenger aircraft have sufficient operating capacity to rise above nearly all cloud which could affect the view.

TOTAL SOLAR ECLIPSE OF 22 JULY 1990

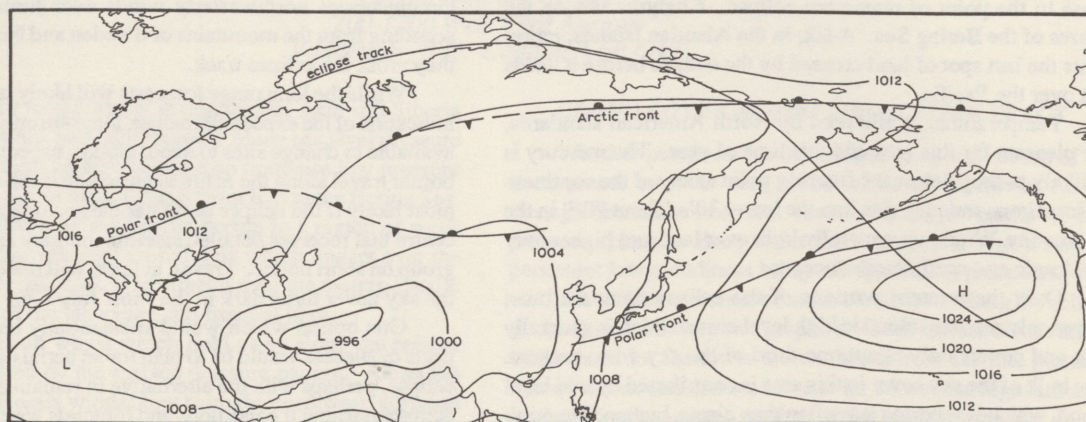


Figure 1: Mean sea level pressure (in millibars) and mean frontal positions for July.

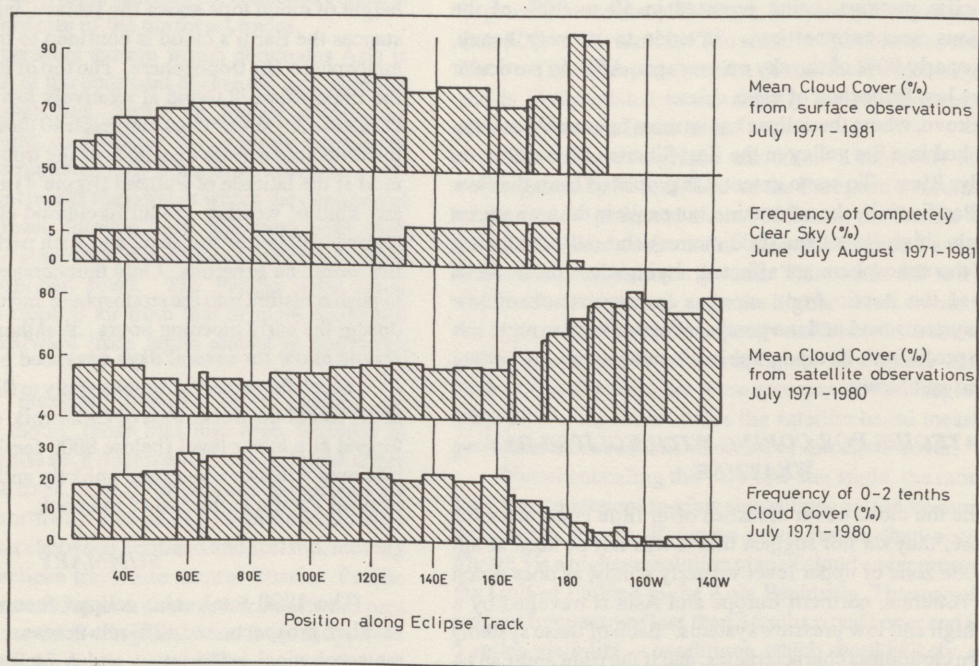


Figure 2: Cloud climatology along the eclipse track. Statistics for the top two graphs are compiled from surface observations; the lower two are from satellite images. Data are extracted for latitude-longitude squares of varying sizes (generally 5 x 10 degrees). The width of each bar is a reflection of the eclipse track across each square.

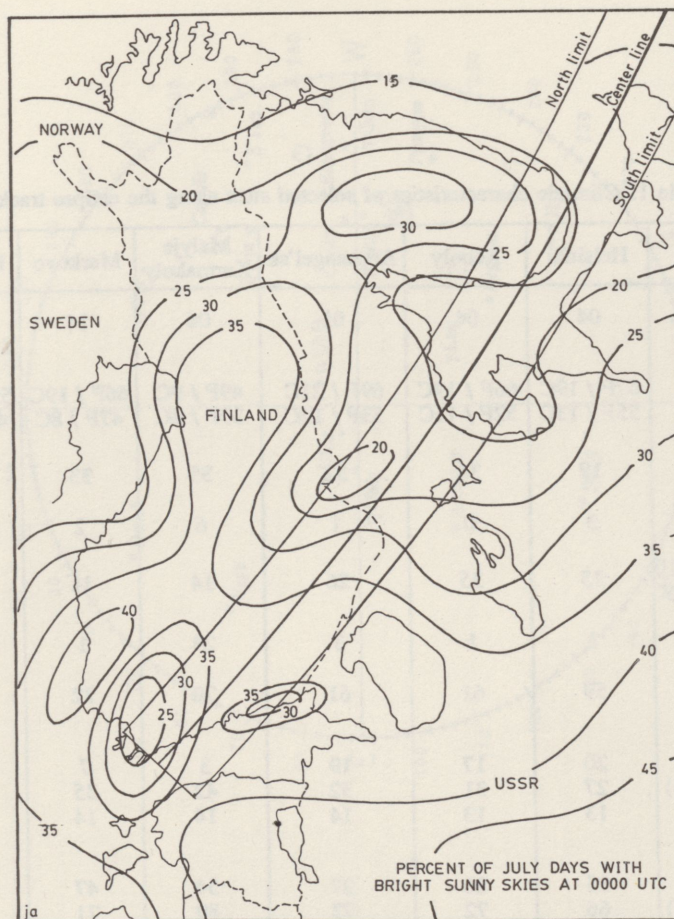


Figure 3: Percent of July days with less than 3/10ths cloud cover and more than 5 miles visibility at 0000 UTC. Eclipse track is approximate.

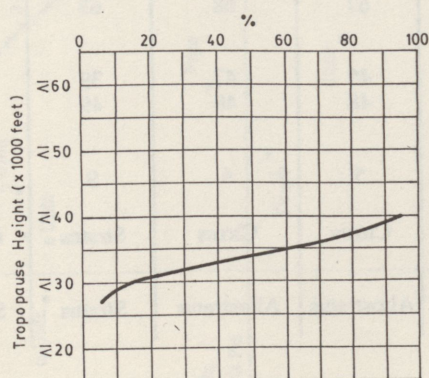


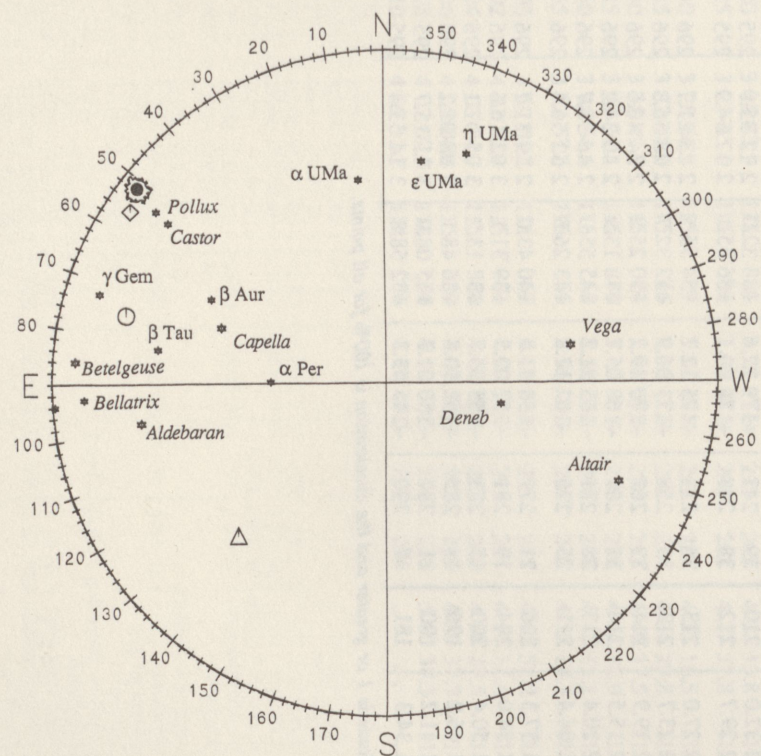
Figure 4: Percent frequency of tropopause heights less than a given value, for 60 degrees north latitude.

Table 1: Climatic characteristics of selected sites along the eclipse track.

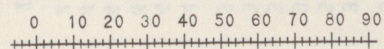
Location:	Helsinki	Reboly	Arkhangel'sk	Malyje Karmakoly	Markovo	Khatyrka	Adak
Approx. hour of eclipse	04	04	05	06	14	15	15
<u>Temperature:</u>							
Mean Maximum	67F / 19C	66F / 19C	69F / 21C	49F / 9C	66F / 19C	55F / 13C	53F / 12C
Mean Minimum	55F / 13C	52F / 11C	53F / 12C	39F / 4C	47F / 8C	43F / 6C	44F / 7C
% days with 2.5+ mm rain	19	34	32	35	33	26	18
% days with thick fog	3	0	1	6	2	18	11
% days with less than 3/10 cloud and good visibility	35	35	26	14	11	22	1
% days with winds under 17 mph	2	1	3	24	1	11	20
Mean cloud cover (%)	59	61	61	70	72	75	93
<u>Cumulus cloud</u>							
Frequency (%)	20	17	19	3	7	8	3
Amount when present (%)	27	31	32	42	35	35	56
Time of Maximum	13	13	14	14	14	14	10
<u>Low Cloud</u>							
Frequency (%)	35	26	27	54	47	52	92
Amount when present (%)	66	72	73	89	71	73	87
Time of maximum	05	06	05	03	03	03	01
<u>Middle Cloud</u>							
Frequency (%)	50	37	42	32	37	38	30
Amount when present (%)	55	67	68	68	66	63	68
<u>High Cloud</u>							
Frequency (%)	57	49	47	39	52	49	52
Amount when present (%)	34	48	48	49	52	51	46
<u>Clear skies</u>							
Frequency (%)	4	5	6	9	7	7	0
Most frequent type of cloud	Cirrus	Cirrus	Cirrus	Stratus	Cirrus	Stratus	Stratus
Cloud type contrib- uting most to cloud cover	Altostratus	Altostratus	Altostratus	Stratus	Stratus	Stratus	Stratus

Sky Diagram for Joensuu, Finland
22 July 1990, 1h 54m UT

Diagram centered on zenith



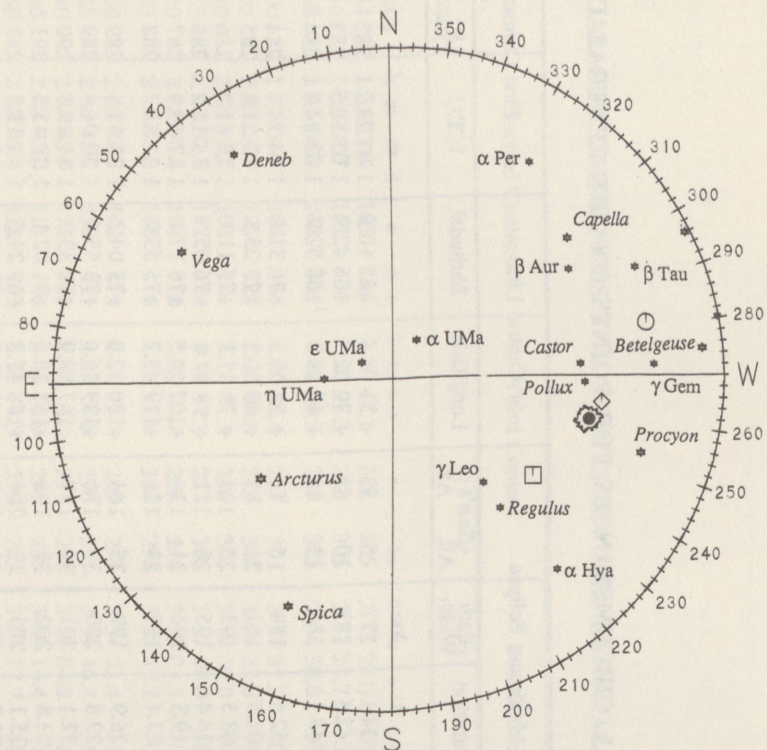
○ = Venus
△ = Mars
◇ = Jupiter



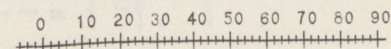
Altitude Scale (degrees)

Sky Diagram for Atka, Alaska, USA
22 July 1990, 3h 35m UT

Diagram centered on zenith



□ = Mercury
○ = Venus
◇ = Jupiter



Altitude Scale (degrees)

LOCAL CIRCUMSTANCES FOR POINTS ON THE CENTRAL LINE

Maximum Eclipse				Central Line		First Contact		
U.T.	Duration	Path Width	Sun's Alt. Az.	Longitude	Latitude	U.T.	P	V
h m	m s	km	° °	° '	° '	h m s	°	°
1 54	1 34.1	177	5 53	+ 31 04.4	+63 10.5	1 02 28.2	283	301
1 56	1 42.5	183	10 61	+ 39 52.5	+66 42.9	1 02 38.5	283	302
1 58	1 48.1	186	13 68	+ 46 18.3	+68 52.9	1 03 24.8	284	302
2 00	1 52.6	188	16 74	+ 52 05.3	+70 31.6	1 04 24.4	284	302
2 05	2 01.5	191	21 89	+ 65 51.5	+73 25.3	1 07 21.4	285	302
2 10	2 08.5	193	25 105	+ 79 45.3	+75 11.1	1 10 41.2	286	302
2 15	2 14.4	195	28 121	+ 93 49.0	+76 05.5	1 14 15.2	286	301
2 20	2 19.3	196	31 136	+107 24.5	+76 17.1	1 17 59.9	287	300
2 25	2 23.4	197	33 151	+119 47.7	+75 53.9	1 21 53.7	288	299
2 30	2 26.9	198	35 164	+130 32.8	+75 04.2	1 25 55.4	289	297
2 35	2 29.8	200	36 176	+139 36.6	+73 55.4	1 30 04.4	289	296
2 40	2 32.1	201	38 187	+147 09.9	+72 33.3	1 34 20.5	290	294
2 45	2 33.8	202	39 196	+153 28.6	+71 02.1	1 38 43.5	291	292
2 50	2 35.1	203	39 204	+158 47.8	+69 24.6	1 43 13.2	291	290
2 55	2 35.8	204	40 212	+163 20.7	+67 42.5	1 47 49.7	292	288
3 00	2 36.0	205	40 219	+167 17.8	+65 57.2	1 52 33.0	293	285
3 05	2 35.7	207	40 225	+170 47.1	+64 09.2	1 57 23.1	293	282
3 10	2 34.9	208	40 232	+173 55.2	+62 18.9	2 02 20.2	294	279
3 15	2 33.7	209	39 237	+176 47.3	+60 26.5	2 07 24.4	294	275
3 20	2 32.0	210	39 243	+179 27.6	+58 32.0	2 12 35.9	295	272
3 25	2 29.7	212	38 248	-178 00.1	+56 35.1	2 17 54.9	295	268
3 30	2 27.0	213	36 253	-175 32.7	+54 35.5	2 23 21.7	296	265
3 35	2 23.7	213	35 258	-173 06.9	+52 32.7	2 28 56.8	296	261
3 40	2 19.9	214	33 263	-170 39.2	+50 25.8	2 34 40.6	296	257
3 45	2 15.5	214	31 267	-168 05.7	+48 13.9	2 40 34.2	296	253
3 50	2 10.4	213	28 271	-165 21.2	+45 55.0	2 46 38.7	296	249
3 55	2 04.4	211	25 275	-162 17.8	+43 26.5	2 52 56.4	296	246
4 00	1 57.3	206	21 279	-158 41.8	+40 43.0	2 59 31.7	296	242
4 02	1 54.0	204	19 281	-157 00.5	+39 31.1	3 02 16.6	296	241
4 04	1 50.4	200	17 283	-155 05.7	+38 13.7	3 05 07.1	296	239
4 06	1 46.2	196	14 285	-152 50.8	+36 48.1	3 08 05.2	296	238
4 08	1 41.2	190	11 287	-150 01.7	+35 08.9	3 11 15.7	295	236
4 10	1 34.3	181	7 290	-145 53.3	+32 58.8	3 14 53.4	295	234

The magnitude is 1 or greater and the obscuration is 100% for all points.

LOCAL CIRCUMSTANCES FOR POINTS ON THE CENTRAL LINE

U.T. at Maximum	Second Contact			Third Contact			Fourth Contact		
	U.T.	P	V	U.T.	P	V	U.T.	P	V
h m	h m s	°	°	h m s	°	°	h m s	°	°
1 54	1 53 13.0	103	125	1 54 47.1	283	305	2 47 29.0	103	129
1 56	1 55 08.7	103	125	1 56 51.3	283	305	2 51 23.7	103	127
1 58	1 57 06.0	104	125	1 58 54.1	284	305	2 54 38.0	104	126
2 00	1 59 03.7	104	124	2 00 56.4	284	304	2 57 37.2	104	125
2 05	2 03 59.3	105	123	2 06 00.8	285	303	3 04 32.0	105	123
2 10	2 08 55.7	106	121	2 11 04.3	286	301	3 10 59.0	106	120
2 15	2 13 52.8	107	120	2 16 07.2	287	300	3 17 08.0	107	117
2 20	2 18 50.4	108	118	2 21 09.7	288	298	3 23 03.3	108	115
2 25	2 23 48.3	108	116	2 26 11.8	288	296	3 28 47.2	109	112
2 30	2 28 46.5	109	113	2 31 13.5	289	293	3 34 21.4	110	109
2 35	2 33 45.1	110	111	2 36 14.9	290	291	3 39 46.8	110	106
2 40	2 38 43.9	110	108	2 41 16.0	291	288	3 45 04.2	111	103
2 45	2 43 43.0	111	106	2 46 16.9	291	286	3 50 14.4	111	100
2 50	2 48 42.4	112	103	2 51 17.5	292	283	3 55 17.7	112	97
2 55	2 53 42.0	112	100	2 56 17.8	292	280	4 00 14.7	112	94
3 00	2 58 41.9	113	97	3 01 17.9	293	277	4 05 05.6	113	91
3 05	3 03 42.0	113	94	3 06 17.8	293	274	4 09 50.7	113	89
3 10	3 08 42.4	114	91	3 11 17.4	294	271	4 14 30.4	114	86
3 15	3 13 43.0	114	88	3 16 16.8	294	268	4 19 04.7	114	84
3 20	3 18 43.9	115	85	3 21 15.9	295	265	4 23 33.8	114	81
3 25	3 23 45.0	115	82	3 26 14.8	295	262	4 27 57.8	115	79
3 30	3 28 46.3	115	79	3 31 13.4	295	259	4 32 16.5	115	76
3 35	3 33 48.0	115	76	3 36 11.8	295	256	4 36 29.8	115	74
3 40	3 38 49.9	116	73	3 41 09.8	296	253	4 40 37.5	115	72
3 45	3 43 52.1	116	70	3 46 07.6	296	250	4 44 38.9	115	70
3 50	3 48 54.6	116	68	3 51 05.1	296	248	4 48 33.1	115	68
3 55	3 53 57.6	116	65	3 56 02.1	296	245	4 52 18.3	115	66
4 00	3 59 01.2	115	62	4 00 58.6	295	242	4 55 51.2	114	64
4 02	4 01 02.8	115	61	4 02 56.9	295	241	4 57 11.4	114	63
4 04	4 03 04.7	115	60	4 04 55.1	295	240	4 58 27.5	114	62
4 06	4 05 06.8	115	59	4 06 53.0	295	239	4 59 37.7	114	61
4 08	4 07 09.3	114	58	4 08 50.5	294	238	5 00 38.3	113	61
4 10	4 09 12.7	114	56	4 10 47.1	294	236	.. ..	...	...

LOCAL CIRCUMSTANCES FOR GEOGRAPHIC LOCATIONS

Position		Name of Location	Duration of Totality	Maximum Eclipse				
Latitude	Longitude			Path Width	U.T.	Obscur.	Mag.	Sun's Alt. Az.
° ' "	° ' "		m s	km	h m s	%		° °
Finland								
+60 24.0	+ 25 40.0	Borga	1 24.8	171	1 53 06.3	100.0	1.011	2 48
+61 00.0	+ 24 25.0	Hameenlinna	0 49.9	174	1 54 16.1	100.0	1.003	2 47
+60 33.0	+ 27 15.0	Hamina	0 48.8	171	1 52 34.4	100.0	1.002	2 49
+61 13.0	+ 26 05.0	Heinola	1 25.5	174	1 53 46.1	100.0	1.010	2 48
+60 09.7	+ 24 57.3	Helsinki (Univ. of Helsinki Obs.)	1 26.2	171	1 53 10.8	100.0	1.012	1 47
+60 37.0	+ 24 50.0	Hyvinkaa	1 24.2	173	1 53 41.7	100.0	1.010	1 47
+62 40.0	+ 30 55.0	Ilomantsi	1 25.8	176	1 53 27.9	100.0	1.009	5 53
+61 14.0	+ 28 50.0	Imatra	0 44.3	172	1 52 39.1	100.0	1.002	3 51
+60 29.0	+ 25 06.0	Jarvenpaa	1 28.0	172	1 53 26.4	100.0	1.014	1 48
+63 41.0	+ 22 40.0	Jakobstad			1 57 46.8	94.5	0.950	3 46
+62 36.0	+ 29 45.0	Joensuu	1 32.8	176	1 53 48.8	100.0	1.015	4 52
+60 32.0	+ 24 10.0	Karkkila	1 15.2	173	1 53 54.6	100.0	1.007	1 47
+60 25.0	+ 25 10.0	Kerava	1 28.0	172	1 53 20.6	100.0	1.014	1 48
+60 13.2	+ 24 23.8	Kirkkonummi (Metsahovi Obs.)	1 26.8	172	1 53 29.5	100.0	1.013	1 47
+60 26.0	+ 26 55.0	Kotka	0 53.1	171	1 52 35.7	100.0	1.003	2 49
+60 54.0	+ 26 45.0	Kouvola	1 25.6	172	1 53 09.2	100.0	1.010	2 49
+62 54.0	+ 27 40.0	Kuopio			1 54 56.1	99.9	0.998	4 50
+61 00.0	+ 25 40.0	Lahti	1 25.5	174	1 53 43.3	100.0	1.011	2 48
+61 04.0	+ 28 15.0	Lappeenranta	0 56.4	172	1 52 42.4	100.0	1.003	3 50
+63 20.0	+ 30 00.0	Lieska	1 17.0	178	1 54 33.5	100.0	1.007	5 52
+60 27.0	+ 26 15.0	Lovisa	1 17.2	171	1 52 54.0	100.0	1.007	2 48
+61 44.0	+ 27 15.0	Mikkeli	1 27.3	175	1 53 49.8	100.0	1.011	3 49
+63 31.0	+ 29 10.0	Nurmes			1 55 04.0	99.9	0.999	5 52
+65 00.0	+ 25 26.0	Oulu			1 58 06.6	94.6	0.952	5 49
+62 43.0	+ 29 05.0	Outokumpu	1 25.3	177	1 54 11.6	100.0	1.009	4 51
+62 18.0	+ 27 10.0	Pieksämäki	0 53.9	177	1 54 28.5	100.0	1.003	3 50
+60 25.0	+ 22 26.8	Piikkio (Turku-Tuorla Obs.)			1 54 35.2	99.5	0.994	1 45
+60 45.0	+ 24 45.0	Riihimäki	1 18.7	173	1 53 52.0	100.0	1.008	1 47
+60 23.0	+ 23 10.0	Salo	0 48.9	173	1 54 13.1	100.0	1.003	1 46
+61 54.0	+ 28 55.0	Savonlinna	1 27.8	174	1 53 20.9	100.0	1.011	4 51
+61 32.0	+ 23 45.0	Tampere			1 55 06.3	99.3	0.991	2 47
+60 27.0	+ 22 15.0	Turku			1 54 42.7	99.5	0.993	1 45
+62 20.0	+ 27 50.0	Varkaus	1 15.8	177	1 54 14.8	100.0	1.007	3 50
U.S.S.R.								
+43 11.3	+ 76 57.4	Alma-Ata (Mountain Obs.)			1 24 31.6	15.8	0.264	18 79
+55 08.0	+ 95 51.0	Ambarchik			1 50 34.8	39.0	0.496	35 105
+64 43.0	+177 30.0	Anadyr			3 07 56.5	95.8	0.959	37 233
+64 32.0	+ 40 40.0	Arkhangelsk			1 52 54.1	96.7	0.968	9 61
+37 57.4	+ 58 21.2	Ashkhabad (Ashkhabad Ap. Lab.)			1 18 21.1	18.2	0.291	3 66
+64 34.0	+ 34 45.0	Belomorsk	1 36.5	179	1 54 29.6	100.0	1.013	7 56
+71 34.0	+ 52 28.0	Belush'ya Guba	0 55.3	191	2 01 35.9	100.0	1.002	17 75
+76 08.0	+ 94 45.0	Birula	2 14.7	195	2 15 20.6	100.0	1.018	28 122
+55 12.0	+ 61 25.0	Chelyabinsk			1 37 29.5	60.0	0.675	13 73
+68 45.0	+161 15.0	Cherskiy	2 33.0	204	2 52 20.0	100.0	1.017	40 208
+73 32.0	+ 80 39.0	Dikson			2 07 43.1	97.5	0.973	25 104
+38 33.7	+ 68 46.9	Dushanbe (Inst. of Astrophys.)			1 17 57.5	11.1	0.208	10 72
+56 15.5	+ 43 59.0	Gor'kiy (Latitude Obs.)			1 41 38.5	77.7	0.818	5 61
+64 08.0	+ 34 21.0	Idel	1 29.2	178	1 54 04.6	100.0	1.009	7 56
+52 16.7	+104 20.7	Irkutsk (Irkutsk Ast. Obs.)			1 56 08.9	28.3	0.395	41 112
+67 09.0	+ 32 31.0	Kandalaksha			1 58 22.4	96.1	0.963	8 56
+55 47.4	+ 49 07.3	Kazan (Kazan Univ. Obs.)			1 39 45.2	72.0	0.773	8 64
+64 58.0	+ 34 39.0	Kem'	1 34.8	181	1 55 01.3	100.0	1.012	7 56
+62 05.0	+175 18.0	Khatyrka	2 20.5	209	3 11 14.0	100.0	1.012	40 234
+39 08.0	+ 66 52.9	Kitab (Inter. Latitude Obs.)			1 18 29.1	13.8	0.241	9 71
+64 03.0	+ 34 14.0	Kochkoma	1 27.7	178	1 54 00.5	100.0	1.009	7 56
+68 50.0	+158 35.0	Kolymskaya	2 13.7	202	2 50 31.5	100.0	1.010	40 204
+70 45.0	+ 54 30.0	Krasino	1 46.3	188	2 00 15.8	100.0	1.011	17 77
+56 05.0	+ 92 46.0	Krasnoyarsk			1 49 18.0	43.0	0.531	33 102
+53 10.0	+ 50 10.0	Kuybyshev			1 36 19.9	64.6	0.713	6 64
+66 15.0	+ 36 51.0	Kuzomen	1 20.2	183	1 56 04.5	100.0	1.006	9 59
+63 21.0	+ 31 12.0	Lendery	1 33.8	178	1 54 09.4	100.0	1.014	5 53
+59 56.5	+ 30 17.7	Leningrad (Leningrad Univ. Obs.)			1 50 39.8	97.0	0.970	3 51
+64 17.0	+ 34 27.0	Letnerechenskiy	1 32.9	179	1 54 13.8	100.0	1.011	7 56
+59 38.0	+150 50.0	Magadan			2 54 51.7	74.3	0.789	50 199
+72 20.0	+ 52 46.0	Malyje Karmakuly			2 02 47.4	97.8	0.976	17 76
+64 40.0	+170 24.0	Markovo	2 32.2	207	3 03 56.3	100.0	1.016	40 224
+62 35.0	+177 26.0	Maynopol'gyn			3 11 35.4	98.4	0.981	38 236
+65 50.0	+ 44 20.0	Mezen'			1 53 55.5	97.4	0.973	11 65
+55 42.0	+ 37 32.7	Moscow (Sternberg State Ast. Inst.)			1 43 10.8	82.2	0.854	2 56
+68 59.0	+ 33 08.0	Murmansk			2 00 34.6	94.5	0.950	10 57
+63 56.0	+ 34 20.0	Nadvoitsy	1 19.7	178	1 53 50.1	100.0	1.007	7 56
+68 34.0	+160 58.0	Nizhnekolymsk	2 35.3	203	2 52 22.8	100.0	1.019	40 208
+74 01.0	+111 30.0	Nordvik			2 19 54.6	97.1	0.971	33 140

Assumed to be sea level.

Names and spelling are not authoritative,
nor do they imply any official recognition of status.No correction for elevation or limb included.
Correction for refraction included.

LOCAL CIRCUMSTANCES FOR GEOGRAPHIC LOCATIONS

Position		First Contact			Second Contact			Third Contact			Fourth Contact		
Latitude	Longitude	U.T.	P	V	U.T.	P	V	U.T.	P	V	U.T.	P	V
°	'	h	m	s	°	'	°	h	m	s	°	'	°
+60 24.0	+ 25 40.0	..	..	..	..	..	..	1 52 23.9	118	142	1 53 48.7	266	289
+61 00.0	+ 24 25.0	..	..	..	..	..	..	1 53 51.1	47	69	1 54 41.1	338	0
+60 33.0	+ 27 15.0	..	..	..	..	..	..	1 52 10.0	159	183	1 52 58.9	225	249
+61 13.0	+ 26 05.0	..	..	..	..	..	..	1 53 03.3	85	108	1 54 28.8	299	322
+60 09.7	+ 24 57.3	..	..	..	..	..	..	1 52 27.7	113	136	1 53 53.9	272	295
+60 37.0	+ 24 50.0	..	..	..	..	..	..	1 52 59.6	85	108	1 54 23.8	299	322
+62 40.0	+ 30 55.0	1 02 04.0	283	302	..	..	..	1 52 45.0	126	149	1 54 10.8	259	282
+61 14.0	+ 28 50.0	..	..	..	..	..	..	1 52 16.9	163	187	1 53 01.3	222	245
+60 29.0	+ 25 06.0	..	..	..	..	..	..	1 52 42.4	99	122	1 54 10.5	285	308
+63 41.0	+ 22 40.0	..	..	..	..	..	..	..	..	..	2 45 32.5	102	129
..	..	..	..	..	..	..	..	..	..	..	2 50 04.8	106	130
+62 36.0	+ 29 45.0	..	..	..	..	..	..	1 53 02.4	102	124	1 54 35.3	283	306
+60 32.0	+ 24 10.0	..	..	..	..	..	..	1 53 17.0	71	94	1 54 32.2	313	336
+60 25.0	+ 25 10.0	..	..	..	..	..	..	1 52 36.6	105	127	1 54 04.6	280	303
+60 13.2	+ 24 23.8	..	..	..	..	..	..	1 52 46.1	95	118	1 54 12.9	289	312
+60 26.0	+ 26 55.0	..	..	..	..	..	..	1 52 09.1	156	179	1 53 02.3	229	252
+60 54.0	+ 26 45.0	..	..	..	..	..	..	1 52 26.4	119	142	1 53 52.0	265	289
+62 54.0	+ 27 40.0	..	..	..	..	..	..	..	..	..	2 47 51.3	104	129
+61 00.0	+ 25 40.0	..	..	..	..	..	..	1 53 00.5	86	109	1 54 26.1	298	321
+61 04.0	+ 28 15.0	..	..	..	..	..	..	1 52 14.2	154	177	1 53 10.6	231	254
+63 20.0	+ 30 00.0	1 03 07.6	282	300	..	..	..	1 53 55.0	68	90	1 55 12.1	317	340
..	..	..	..	..	..	..	..	..	..	..	2 47 54.3	103	129
+60 27.0	+ 26 15.0	..	..	..	..	..	..	1 52 15.4	132	155	1 53 32.6	253	276
+61 44.0	+ 27 15.0	..	..	..	..	..	..	1 53 06.1	87	110	1 54 33.5	298	320
+63 31.0	+ 29 10.0	1 03 41.9	282	300	..	..	..	..	..	..	2 46 28.8	103	129
+65 00.0	+ 25 26.0	1 06 53.6	280	296	..	..	..	..	..	..	2 48 19.1	104	129
+62 43.0	+ 29 05.0	..	..	..	..	..	..	1 53 29.0	80	102	2 51 02.0	106	129
+62 18.0	+ 27 10.0	..	..	..	..	..	..	1 54 01.6	49	71	2 47 17.7	103	129
+60 25.0	+ 22 26.8	..	..	..	..	..	..	..	..	..	2 47 12.8	103	129
+60 45.0	+ 24 45.0	..	..	..	..	..	..	1 53 12.7	75	98	2 46 17.6	103	129
+60 23.0	+ 23 10.0	..	..	..	..	..	..	1 53 48.7	46	69	2 45 58.0	103	129
+61 54.0	+ 28 55.0	..	..	..	..	..	..	1 52 37.0	119	142	2 46 01.3	103	129
..	..	..	..	..	..	..	..	..	..	..	2 46 16.7	102	129
+61 32.0	+ 23 45.0	..	..	..	..	..	..	..	..	..	2 47 12.0	104	129
+60 27.0	+ 22 15.0	..	..	..	..	..	..	..	..	..	2 46 23.8	103	129
+62 20.0	+ 27 50.0	..	..	..	..	..	..	1 53 36.9	68	91	2 47 05.6	103	129
..	..	..	..	..	..	..	..	..	..	..	..	..	..
+43 11.3	+ 76 57.4	0 44 16.3	329	17	..	..	..	..	..	..	2 07 21.6	54	105
+55 08.0	+ 95 51.0	0 53 49.0	315	353	..	..	..	..	..	..	2 50 55.6	75	108
+64 43.0	+177 30.0	2 01 52.5	290	275	..	..	..	..	..	..	4 11 10.4	116	91
+64 32.0	+ 40 40.0	0 59 52.9	285	305	..	..	..	..	..	..	2 48 06.4	101	127
+37 57.4	+ 58 21.2	..	..	..	..	..	..	..	..	..	1 57 35.1	54	107
+64 34.0	+ 34 45.0	1 02 13.0	283	302	1 53 41.3	111	134	1 55 17.9	274	297	2 48 46.5	103	128
+71 34.0	+ 52 28.0	1 05 50.0	283	301	2 01 08.2	44	63	2 02 03.6	345	4	2 59 17.9	105	125
+76 08.0	+ 94 45.0	1 14 30.5	286	301	2 14 13.2	106	119	2 16 28.0	287	300	3 17 32.5	107	117
+55 12.0	+ 61 25.0	0 45 12.1	301	334	..	..	..	..	..	..	2 33 00.3	83	120
+68 45.0	+161 15.0	1 45 26.6	291	289	2 51 03.4	102	92	2 53 36.5	302	291	3 57 32.2	112	96
..	..	..	..	..	..	..	..	..	..	..	..	..	..
+73 32.0	+ 80 39.0	1 08 08.5	287	305	..	..	..	..	..	..	3 09 10.7	104	120
+38 33.7	+ 68 46.9	0 43 37.8	332	23	..	..	..	..	..	..	1 54 10.0	48	102
+56 15.5	+ 43 59.0	..	..	..	..	..	..	..	..	..	2 35 21.8	91	125
+64 08.0	+ 34 21.0	1 01 56.5	283	302	1 53 19.9	126	148	1 54 49.2	260	283	2 48 13.6	102	128
+52 16.7	+104 20.7	1 00 30.0	323	3	..	..	..	..	..	..	2 55 04.0	70	101
+67 09.0	+ 32 31.0	1 05 52.3	281	297	..	..	..	..	..	..	2 52 41.0	106	128
+55 47.4	+ 49 07.3	0 48 20.7	295	324	..	..	..	..	..	..	2 33 58.7	88	124
+64 58.0	+ 34 39.0	1 02 40.5	283	301	1 54 13.9	88	111	1 55 48.7	297	319	2 49 21.1	103	128
+62 05.0	+175 18.0	2 03 47.5	293	277	3 10 03.6	90	66	3 12 24.2	318	294	4 15 27.1	114	86
+39 08.0	+ 66 52.9	0 42 20.9	329	18	..	..	..	..	..	..	1 56 41.0	51	104
..	..	..	..	..	..	..	..	..	..	..	..	..	..
+64 03.0	+ 34 14.0	1 01 54.4	283	302	1 53 16.7	128	150	1 54 44.5	258	281	2 48 07.7	102	128
+68 50.0	+158 35.0	1 43 26.1	292	291	2 49 24.5	143	134	2 51 38.3	261	251	3 56 04.2	112	96
+70 45.0	+ 54 30.0	1 04 19.1	284	303	1 59 22.7	126	146	2 01 09.0	263	283	2 58 15.3	104	125
+56 05.0	+ 92 46.0	0 52 21.0	313	349	..	..	..	..	..	..	2 49 51.8	77	109
+53 10.0	+ 50 10.0	..	..	..	..	..	..	..	..	..	2 29 34.1	84	122
+66 15.0	+ 36 51.0	1 03 11.7	283	301	1 55 24.4	66	88	1 56 44.6	320	342	2 50 56.1	104	128
+63 21.0	+ 31 12.0	1 02 34.6	283	301	1 53 22.5	96	119	1 54 56.3	289	312	2 47 41.4	103	129
+59 56.5	+ 30 17.7	..	..	..	..	..	..	..	..	..	2 43 25.0	100	128
+64 17.0	+ 34 27.0	1 02 03.1	283	302	1 53 27.4	120	142	1 55 00.4	266	289	2 48 25.3	103	128
+59 38.0	+150 50.0	1 43 50.9	306	310	..	..	..	..	..	..	4 03 44.9	101	80
..	..	..	..	..	..	..	..	..	..	..	..	..	..
+72 20.0	+ 52 46.0	1 06 54.7	283	300	..	..	..	..	..	..	3 00 32.2	106	125
+64 40.0	+170 24.0	1 56 27.3	293	282	3 02 40.1	102	83	3 05 12.3	305	286	4 08 44.9	113	90
+62 35.0	+177 26.0	2 04 47.6	292	275	..	..	..	..	..	..	4 15 12.8	115	87
+65 50.0	+ 44 20.0	1 00 09.3	285	306	..	..	..	..	..	..	2 49 54.5	101	127
+55 42.0	+ 37 32.7	..	..	..	..	..	..	..	..	..	2 35 52.9	93	126
+68 59.0	+ 33 08.0	1 07 40.3	280	296	..	..	..	..	..	..	2 55 12.4	107	128
+63 56.0	+ 34 20.0	1 01 44.7	283	302	1 53 10.3	137	160	1 54 30.0	248	271	2 47 57.0	102	128
+68 34.0	+160 58.0	1 45 22.3	292	289	2 51 05.1	115	105	2 53 40.5	289	278	3 57 41.5	112	96
+74 01.0	+111 30.0	1 16 43.3	290	304	..	..	..	..	..	..	3 24 14.7	106	112

Dot leaders indicate the phenomenon occurs below the horizon. Blanks indicate the phenomenon does not occur for the location.
Times of second and third contacts include refraction correction.

LOCAL CIRCUMSTANCES FOR GEOGRAPHIC LOCATIONS

Position		Name of Location	Duration of Totality	Maximum Eclipse					Sun's	
Latitude	Longitude			Path Width	U.T.	Obscur.	Mag.		Alt.	Az.
° ' "	° ' "		m s	km	h m s	%			°	°
U.S.S.R. (cont.)										
+55 04.0	+ 83 05.0	Novosibirsk			1 42 06.7	44.4	0.543		26	92
+63 53.0	+ 33 05.0	Ondozero	1 35.0	178	1 54 09.9	100.0	1.013		6	55
+68 07.0	+164 13.0	Ostrovnoye	2 07.7	206	2 55 00.3	100.0	1.009		39	213
+63 12.0	+ 33 20.0	Padany	0 48.5	176	1 53 15.8	100.0	1.002		6	55
+53 03.0	+158 43.0	Petropavlovsk-Kamchatskiy			3 12 58.9	66.8	0.729		52	221
+61 46.0	+ 34 19.0	Petrozavodsk			1 51 14.2	96.7	0.968		5	55
+67 02.0	+ 41 03.0	Ponoy	1 43.1	183	1 56 11.7	100.0	1.015		11	63
+63 25.0	+ 34 02.0	Popov Porog	0 35.3	176	1 53 18.0	100.0	1.001		6	55
+59 46.4	+ 30 19.6	Pulkovo (Main Ast. Obs.)			1 50 28.1	96.8	0.969		3	51
+63 50.0	+ 30 49.0	Reboly	1 08.5	180	1 54 51.2	100.0	1.005		5	53
+64 01.0	+ 32 46.0	Rugozero	1 35.4	179	1 54 25.6	100.0	1.014		6	55
+39 40.6	+ 67 01.5	Samarkand (Ouloug-Beg Obs.)			1 19 02.2	14.9	0.254		9	71
+63 42.0	+ 34 19.0	Segezha	1 00.9	177	1 53 33.3	100.0	1.003		7	56
+67 47.0	+ 44 13.0	Shoyna	1 37.4	184	1 56 41.6	100.0	1.010		12	66
+64 27.0	+ 34 30.0	Sosnovets	1 36.1	179	1 54 25.3	100.0	1.013		7	56
+63 11.0	+ 32 18.0	Sukkozero	1 23.5	176	1 53 35.2	100.0	1.008		6	54
+64 12.0	+ 35 29.0	Sumskiy Posad	1 04.4	178	1 53 49.4	100.0	1.004		7	57
+56 52.0	+ 60 35.0	Sverdlovsk			1 39 45.3	65.1	0.717		14	74
+61 07.0	+ 28 50.0	Svetogorsk	0 16.4	172	1 52 31.5	100.0	1.000		3	51
+71 20.0	+150 20.0	Tabor	2 17.7	200	2 42 48.0	100.0	1.011		39	191
+59 22.0	+ 24 48.0	Tallinn	0 42.9	168	1 52 27.5	100.0	1.002		1	47
+58 22.8	+ 26 43.3	Tartu (Wilhelm Struve Ap. Obs.)			.. .. .	.. .	.. .		..	..
+41 19.5	+ 69 17.6	Tashkent (Tashkent Obs.)			1 20 52.2	16.9	0.277		12	73
+56 28.1	+ 84 56.8	Tomsk (Tomsk Univ. Obs.)			1 44 55.7	47.6	0.571		28	95
+63 59.0	+ 33 30.0	Vacha	1 34.2	178	1 54 09.2	100.0	1.012		6	55
+43 09.0	+131 53.0	Vladivostok			2 44 14.7	11.0	0.206		66	160
+67 27.0	+ 64 00.0	Vorkuta			1 55 22.8	89.9	0.913		19	83
+62 08.0	+ 30 45.0	Vyatsilya	0 52.4	174	1 52 55.0	100.0	1.003		4	52
+60 45.0	+ 28 41.0	Vyborg			1 52 11.4	97.5	0.975		3	50
+62 10.0	+129 50.0	Yakutsk			2 30 07.2	65.8	0.721		47	160
United States										
+51 52.0	-176 40.0	Adak, Alaska			3 34 39.1	97.6	0.974		37	255
+61 10.0	-150 00.0	Anchorage, Alaska			3 24 00.6	70.9	0.763		23	271
+52 14.0	-174 15.0	Atka, Alaska	1 31.0	211	3 35 06.0	100.0	1.004		35	257
+52 55.0	+173 11.0	Attu, Alaska			3 26 22.9	86.1	0.882		44	242
+71 16.0	-156 50.0	Barrow, Alaska			3 04 35.4	71.1	0.765		26	255
+60 49.0	-161 49.0	Bethel, Alaska			3 23 00.2	81.2	0.844		29	260
+65 06.2	-147 27.1	Chatanika (Incoherent Scatter Fac.)			3 16 55.5	67.2	0.734		23	270
+51 25.0	+179 15.0	Constantine Harbor, Alaska			3 33 16.4	91.5	0.925		40	251
+53 55.0	-166 36.0	Dutch Harbor, Alaska			3 34 44.2	93.6	0.942		31	263
+64 50.0	-147 50.0	Fairbanks, Alaska			3 17 24.2	67.5	0.736		23	270
+55 10.0	-162 47.0	Fort Randall, Alaska			3 33 23.0	87.7	0.896		29	265
+21 19.0	-157 50.0	Honolulu, Hawaii			4 28 49.3	62.2	0.694		9	288
+61 29.0	-166 10.0	Hooper Bay, Alaska			3 20 36.4	84.7	0.872		31	255
+58 18.0	-134 25.0	Juneau, Alaska			3 28 03.1	61.4	0.687		14	286
+57 49.0	-152 30.0	Kodiak, Alaska			3 29 59.0	75.2	0.798		23	272
+62 58.0	-155 40.0	McGrath, Alaska			3 20 07.5	74.3	0.790		26	264
+28 12.0	-177 24.0	Midway Islands			4 18 15.2	50.3	0.594		30	278
+37 20.6	-121 38.2	Mt. Hamilton, Cal. (Lick Obs.)			.. .. .	.. .	.. .		..	..
+64 30.0	-165 30.0	Nome, Alaska			3 15 10.7	81.4	0.846		30	253
+45 32.0	-122 40.0	Portland, Oregon			3 43 18.6	65.1	0.718		1	299
+37 45.0	-122 27.0	San Francisco, California			.. .. .	.. .	.. .		..	..
+47 35.0	-122 20.0	Seattle, Washington			3 40 24.2	62.7	0.698		2	299
+47 40.0	-117 25.0	Spokane, Washington			.. .. .	.. .	.. .		..	..
Canada										
+51 05.0	-114 05.0	Calgary, Alberta			3 31 43.5	56.0	0.643		1	304
+64 04.0	-139 24.0	Dawson, Yukon			3 18 42.8	62.4	0.695		19	278
+53 23.4	-113 45.5	Devon (Devon Ast. Obs.)			3 28 32.2	54.3	0.629		2	303
+53 34.0	-113 25.0	Edmonton, Alberta			3 28 08.4	54.1	0.627		2	303
+49 19.2	-119 37.2	Penticton (Dominion Radio Ap. Obs.)			3 36 46.8	59.7	0.674		2	300
+54 18.0	-130 17.0	Prince Rupert, British Columbia			3 33 34.0	61.3	0.686		10	291
+49 15.2	-123 13.9	Vancouver (Univ. of B.C. Obs.)			3 38 30.8	61.5	0.688		3	298
+48 31.2	-123 25.0	Victoria (Dominion Ap. Obs.)			3 39 36.8	62.3	0.695		3	298
+60 41.0	-135 08.0	Whitehorse, Yukon			3 24 09.3	60.9	0.683		16	284
+62 30.0	-114 29.0	Yellowknife, Northwest Territories			3 16 06.9	51.3	0.603		8	299
Other										
+76 35.0	- 68 30.0	Dundas, Greenland			2 42 43.7	53.4	0.621		9	332
+35 56.3	+138 28.8	Nobeyama Solar Radio Obs., Japan			3 09 37.0	2.4	0.073		74	195
+36 06.8	+137 33.3	Norikura Solar Obs., Japan			3 07 08.0	2.0	0.066		74	189
+59 56.0	+ 10 45.0	Oslo, Norway			.. .. .	.. .	.. .		..	..
+43 05.0	+141 21.0	Sapporo, Japan			3 03 48.5	19.3	0.302		67	194
+59 20.0	+ 18 05.0	Stockholm, Sweden			.. .. .	.. .	.. .		..	..
+35 40.0	+139 45.0	Tokyo, Japan			3 13 01.8	2.9	0.083		74	202
+47 54.0	+106 52.0	Ulaanbaatar, Mongolia			1 55 57.6	15.5	0.260		44	111

Assumed to be sea level.

Names and spelling are not authoritative,
nor do they imply any official recognition of status.No correction for elevation or limb included.
Correction for refraction included.

LOCAL CIRCUMSTANCES FOR GEOGRAPHIC LOCATIONS

Position		First Contact			Second Contact			Third Contact			Fourth Contact		
Latitude	Longitude	U.T.	P	V	U.T.	P	V	U.T.	P	V	U.T.	P	V
° ' "	° ' "	h m s	° ' "	° ' "	h m s	° ' "	° ' "	h m s	° ' "	° ' "	h m s	° ' "	° ' "
+55 04.0	+ 83 05.0	0 47 31.8	311	348							2 40 21.2	76	113
+63 53.0	+ 33 05.0	1 02 14.4	283	302	1 53 22.4	111	133	1 54 57.5	275	297	2 48 04.7	103	128
+68 07.0	+164 13.0	1 48 07.7	291	286	2 53 56.3	78	66	2 56 04.1	327	314	3 59 58.3	113	95
+63 12.0	+ 33 20.0	1 01 27.3	283	303	1 52 51.6	162	185	1 53 40.1	223	246	2 47 05.9	102	128
+53 03.0	+158 43.0	2 01 10.2	312	304							4 20 52.5	100	65
+61 46.0	+ 34 19.0	0 59 37.9	285	305							2 44 57.5	100	128
+67 02.0	+ 41 03.0	1 02 37.4	283	302	1 55 20.2	109	130	1 57 03.3	278	300	2 51 48.8	103	127
+63 25.0	+ 34 02.0	1 01 21.5	283	303	1 53 00.3	171	194	1 53 35.7	214	237	2 47 16.8	102	128
+59 46.4	+ 30 19.6	.. ..	..	..							2 43 11.5	100	128
+63 50.0	+ 30 49.0	1 03 13.1	282	300	1 54 16.9	59	81	1 55 25.5	326	348	2 48 24.6	103	129
+64 01.0	+ 32 46.0	1 02 30.8	283	301	1 53 37.9	97	119	1 55 13.4	289	311	2 48 18.8	103	128
+39 40.6	+ 67 01.5	0 42 01.5	328	17							1 58 12.3	52	105
+63 42.0	+ 34 19.0	1 01 31.0	283	303	1 53 02.9	154	177	1 54 03.8	232	255	2 47 37.7	102	128
+67 47.0	+ 44 13.0	1 02 34.2	284	303	1 55 53.0	127	148	1 57 30.4	260	282	2 52 53.8	103	127
+64 27.0	+ 34 30.0	1 02 12.1	283	302	1 53 37.3	112	134	1 55 13.4	274	296	2 48 38.8	103	128
+63 11.0	+ 32 18.0	1 01 54.4	283	302	1 52 53.4	131	154	1 54 17.0	254	277	2 47 15.6	102	128
+64 12.0	+ 35 29.0	1 01 31.9	283	303	1 53 17.2	151	174	1 54 21.6	234	257	2 48 09.6	102	128
+56 52.0	+ 60 35.0	0 46 43.6	299	331							2 35 56.6	85	121
+61 07.0	+ 28 50.0	.. ..	..	..	1 52 23.3	182	205	1 52 39.7	203	226	2 45 17.7	101	129
+71 20.0	+150 20.0	1 36 33.4	291	294	2 41 39.1	138	134	2 43 56.8	264	260	3 48 12.2	111	101
+59 22.0	+ 24 48.0	.. ..	..	..	1 52 06.0	162	186	1 52 48.9	222	245	2 44 18.1	101	129
+58 22.8	+ 26 43.3	.. ..	..	..							2 42 30.1	100	128
+41 19.5	+ 69 17.6	0 41 51.3	327	14							2 02 16.9	54	106
+56 28.1	+ 84 56.8	0 49 02.6	309	345							2 44 27.1	79	113
+63 59.0	+ 33 30.0	1 02 09.4	283	302	1 53 22.1	115	137	1 54 56.4	271	294	2 48 08.9	103	128
+43 09.0	+131 53.0	1 52 34.9	346	20							3 35 39.5	63	55
+67 27.0	+ 64 00.0	0 58 33.4	290	312							2 54 44.0	99	123
+62 08.0	+ 30 45.0	.. ..	..	..	1 52 28.8	158	181	1 53 21.2	227	250	2 46 09.9	102	128
+60 45.0	+ 28 41.0	.. ..	..	..							2 44 52.1	101	129
+62 10.0	+129 50.0	1 21 51.1	307	326							3 38 57.1	95	92
+51 52.0	-176 40.0	2 27 23.9	299	264							4 37 09.4	113	71
+61 10.0	-150 00.0	2 26 26.7	278	248							4 18 48.9	126	96
+52 14.0	-174 15.0	2 28 38.9	297	262	3 34 20.4	167	127	3 35 51.4	244	204	4 36 55.2	114	73
+52 55.0	+173 11.0	2 16 26.5	304	279							4 31 38.4	108	69
+71 16.0	-156 50.0	2 06 07.5	277	259							4 01 08.5	125	105
+60 49.0	-161 49.0	2 21 40.6	284	255							4 21 08.2	123	91
+65 06.2	-147 27.1	2 20 15.3	276	250							4 11 14.9	128	101
+51 25.0	+179 15.0	2 24 46.2	302	269							4 36 53.2	110	69
+53 55.0	-166 36.0	2 31 02.0	291	255							4 34 17.7	118	79
+64 50.0	-147 50.0	2 20 37.1	276	250							4 11 48.4	127	101
+55 10.0	-162 47.0	2 31 07.6	288	253							4 31 47.8	120	83
+21 19.0	-157 50.0	3 34 39.2	315	241							.. ..	..	..
+61 29.0	-166 10.0	2 18 01.7	285	259							4 19 57.4	121	91
+58 18.0	-134 25.0	2 35 13.1	273	239							4 18 33.2	130	99
+57 49.0	-152 30.0	2 31 27.6	281	247							4 25 21.9	125	91
+62 58.0	-155 40.0	2 20 56.9	280	253							4 16 31.3	125	96
+28 12.0	-177 24.0	3 17 45.9	324	254							5 13 13.4	93	27
+37 20.6	-121 38.2	3 04 07.3	280	229							.. ..	..	..
+64 30.0	-165 30.0	2 13 21.6	283	260							4 14 10.0	122	95
+45 32.0	-122 40.0	2 54 08.5	274	230							.. ..	..	..
+37 45.0	-122 27.0	3 03 56.2	280	229							.. ..	..	..
+47 35.0	-122 20.0	2 51 17.2	273	231							.. ..	..	..
+47 40.0	-117 25.0	2 49 54.6	272	230							.. ..	..	..
+51 05.0	-114 05.0	2 44 24.0	269	231							.. ..	..	..
+64 04.0	-139 24.0	2 24 14.5	273	245							4 11 00.2	129	103
+53 23.4	-113 45.5	2 41 10.1	268	232							.. ..	..	..
+53 34.0	-113 25.0	2 40 49.8	268	232							.. ..	..	..
+49 19.2	-119 37.2	2 48 17.0	271	231							.. ..	..	..
+54 18.0	-130 17.0	2 42 05.9	273	235							4 22 42.5	130	97
+49 15.2	-123 13.9	2 49 07.9	273	231							.. ..	..	..
+48 31.2	-123 25.0	2 50 12.1	273	231							.. ..	..	..
+60 41.0	-135 08.0	2 31 00.0	273	241							4 15 04.2	130	101
+62 30.0	-114 29.0	2 27 38.4	266	238							4 03 05.7	133	111
+76 35.0	- 68 30.0	1 54 18.0	264	255							3 30 48.8	129	125
+35 56.3	+138 28.8	2 36 13.0	6	18							3 42 16.6	51	18
+36 06.8	+137 33.3	2 35 18.9	7	22							3 38 20.2	49	21
+59 56.0	+ 10 45.0	.. ..	..	..							2 50 13.4	107	130
+43 05.0	+141 21.0	2 03 34.2	340	358							4 01 57.1	73	41
+59 20.0	+ 18 05.0	.. ..	..	..							2 46 38.4	104	130
+35 40.0	+139 45.0	2 37 40.9	5	12							3 47 27.1	52	15
+47 54.0	+106 52.0	1 06 54.2	334	19							2 47 44.6	60	96

Dot leaders indicate the phenomenon occurs below the horizon. Blanks indicate the phenomenon does not occur for the location.
Times of second and third contacts include refraction correction.

LIMB CORRECTIONS

The information below is based largely on the article, "Correcting Predictions of Solar Eclipse Contact Times for the Effects of Lunar Limb Irregularities", *J. Brit. Astron. Assoc.* 1983, 93, 6, pp. 241-246, by David Herald of Woden, A. C. T., Australia. Mr. Herald's new, improved charts for this eclipse appear on the next page.

For locations in the central path of a solar eclipse, predicted times of second and third contacts are computed on the assumption that the Moon is a smooth circular body. However, in the strict sense this is not true, and, in particular, the irregular limb of the Moon introduces a change into those predicted contact times which may potentially amount to several seconds at locations well away from the central line. The change is caused by two different effects of the irregular limb.

First, the position and motion of the Moon are calculated from gravitational theory which deals only with a point mass, or center of gravity. However, the observed eclipse phenomena are caused by the apparent figure, and the Moon is such an irregular body that the centers of figure and mass do not coincide. Therefore, in predicting the contacts, corrections have been applied to the lunar ephemeris for the offset of the center of figure from the center of mass (or motion), and a mean lunar profile radius, k , has been used in the calculations. (See Elements of the Eclipse.)

The predicted second and third contacts are defined as the instants at which the solar limb is tangential to the mean lunar limb, but does not intersect it at any point. However, applying this definition to the irregular true lunar limb, one can see by inspection of the profile (page 26) that for any given point of predicted contact on the smooth mean limb, there is some irregular valley feature in the vicinity whose innermost (deepest) point will define the true contact. Then the operational definition of the second and third contacts is whether or not any light from the photosphere is visible. In general, but not always, second contact will be later than predicted, and third contact earlier.

The plot of the lunar limb shows the difference between the true limb and the mean limb exaggerated 70 to 1 on the radial scale. If the solar limb relative to the mean lunar limb is plotted using the same exaggerated radial scale, at the time of predicted second or third contact, it forms an epicyclic curve separating from the lunar limb rapidly with position angle away from the predicted contact point. Furthermore, if this epicyclic curve representing the solar limb, is plotted for a sequence of times at small intervals, the sequence of curves progresses essentially along the radial direction from the mean limb at the contact point. Hence, in effect, when this epicyclic curve is shifted radially so as to be tangent to the true irregular limb at some valley point which may lie well off the cited radius, the displacement of the solar limb from the predicted contact point, in seconds of arc, is ascertained for that position angle. The locus of such displacements for all position angles is a curve representing the displacement of the solar limb from the mean lunar limb at the true time it contacts the true lunar limb at any given position angle of contact. In other words, it is the operational lunar limb for predicting contact times.

To use this displacement curve to correct predicted contact times for the mean limb, it is necessary to relate the displacement in seconds of arc to a time interval. This is most conveniently achieved by plotting along with the displacement curve already described another curve representing the locus of the displacement of the solar limb at each position angle at some specified constant time interval (e.g. 10 seconds) from the mean-limb contact time. The ratio of the displacement of the solar limb at true contact to the displacement in a constant time interval then gives directly the correction to be applied to account for the effect of the lunar limb features.

The first curve, for displacement from predicted contact, is nearly the same for the entire eclipse track, but the curve for displacement of the solar limb in 10 seconds is location-dependent and should be calculated for each major observing region in the path.

On the facing page is a pair of correction diagrams for Joensuu, Finland. It is oriented to match the limb profile diagram, so that north is up and east is left. Conceptually, time flows left to right. The left-hand diagram is for second contact, the right hand one is for third contact. The vertical line in each diagram represents the instant of the mean, smooth-limb, predicted contact. The smooth curved lines represent the relative displacement of the solar limb in 10 seconds. Position angles are marked on the vertical. The irregular curves running vertically represent the displacement at the instant of contact with the true, irregular limb, i.e., the operational lunar limb.

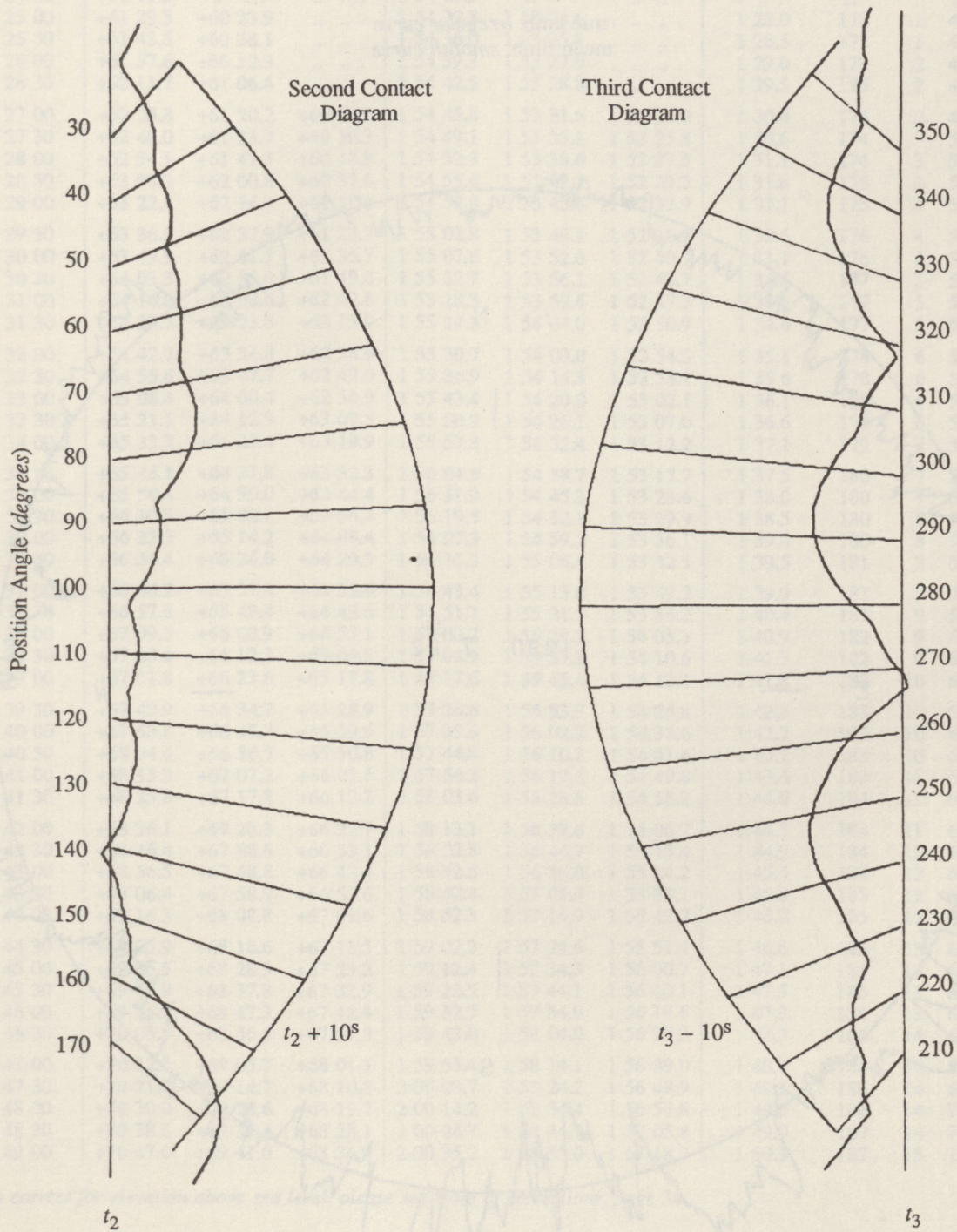
To get the correction for a specific location, first obtain the predicted times and position angles of the second and third contacts, either from the tables or by estimation as described elsewhere. On the vertical lines, find each position angle and lay a ruler from that point to the associated point on the smooth solar limb displacement curve. Measure the distance between those two points, and the distance from the vertical line to the irregular displacement curve. Divide the second measure by the first and multiply by 10 to get the correction in seconds of time. For second contact, if the two curve points are on the same side of the vertical line, add the correction to the predicted time; otherwise, subtract. For third contact, if the two curve points are on the same side of the vertical line, subtract the correction from the predicted contact time; otherwise, add it.

During the time interval between predicted and corrected times, Bailey's Bead effects may appear.

EXAMPLE: At Joensuu, from the Local Circumstances table, the position angles are 102° (second contact) and 283° (third contact). On the second contact (left) diagram, for angle 102° , the displacement curve lies about 4/59 of the distance to the solar limb curve, both curves on the same side of the vertical line; hence, the time correction is $+0^s.7$. Similarly, on the third contact (right) diagram, for angle 283° , the ratio of the distances is approximately 12/58 with both curves on the same side of the vertical line; thus, the time correction is $-2^s.1$. Applying these corrections to the predicted times gives 01h 53m 03.1s UT for second contact and 01h 54m 33.2s UT for third contact.

LUNAR PROFILE CORRECTION DIAGRAMS

Joensuu, Finland

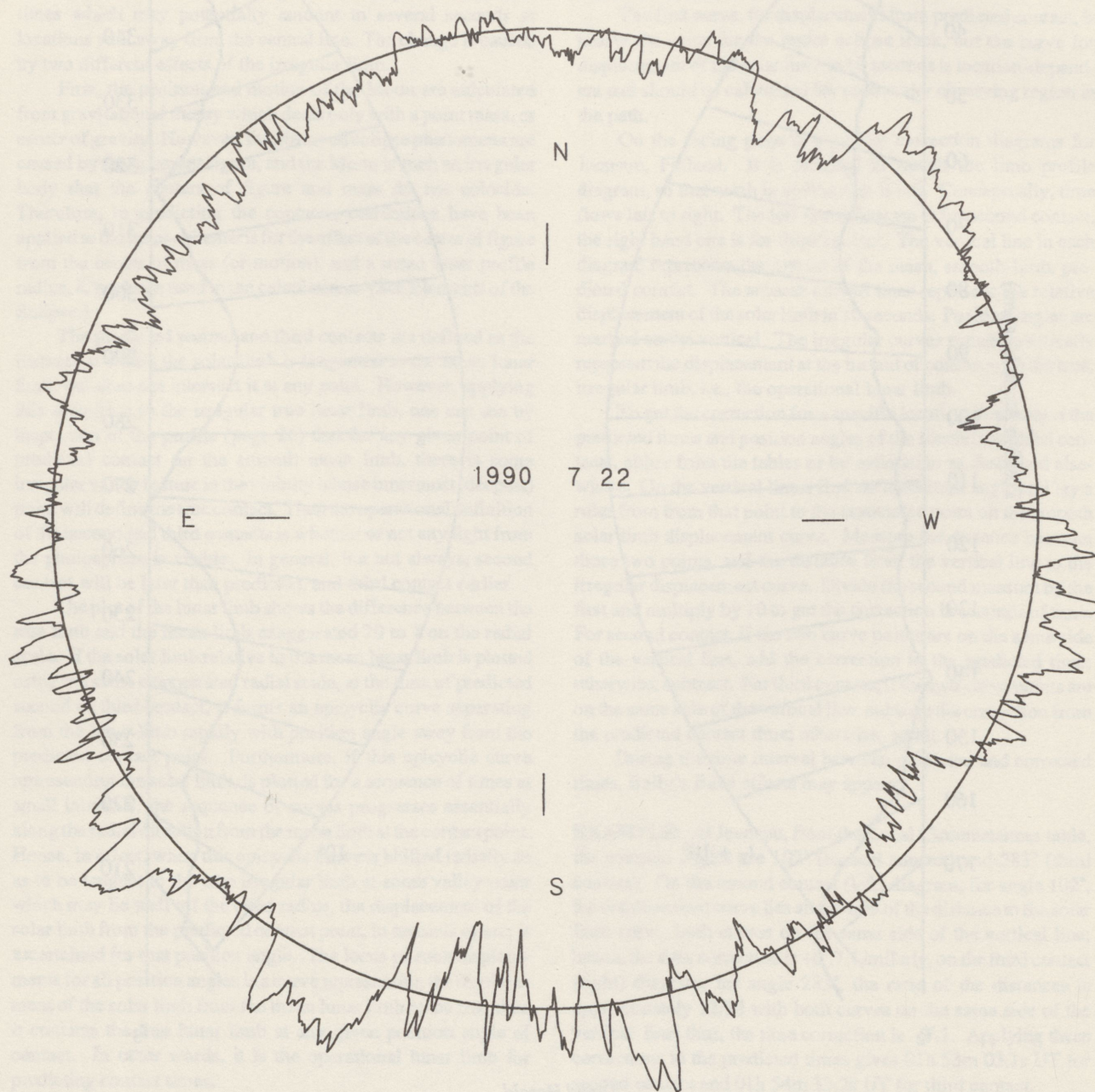


David Herald
P. O. Box 254
Woden, A. C. T. 2606
AUSTRALIA

LUNAR LIMB PROFILE

Radial scale at limb: 4 arcsec/inch

true limb: irregular curve
mean limb: smooth curve



SURFACE PATH OF THE TOTAL PHASE OVER LAND

Longitude	Latitude of:			Universal Time at:			On Central Line			
	Northern Limit	Central Line	Southern Limit	Northern Limit	Central Line	Southern Limit	Maximum Duration	Path Width	Sun's Alt.	Sun's Az.
° ' "	° ' "	° ' "	° ' "	h m s	h m s	h m s	m s	km	° ' "	° ' "
+ 24 30	+61 15.2	.. ..	.. ..	1 54 29.5	.. ..	.. ..	.. ..	.. ..	.. ..	.. ..
+ 25 00	+61 29.3	+60 23.9	.. ..	1 54 32.8	1 53 24.6	.. ..	1 28.0	172	1	47
+ 25 30	+61 43.5	+60 38.1	.. ..	1 54 36.0	1 53 25.8	.. ..	1 28.5	172	1	48
+ 26 00	+61 57.6	+60 52.3	.. ..	1 54 39.3	1 53 27.0	.. ..	1 29.0	173	2	48
+ 26 30	+62 11.7	+61 06.4	.. ..	1 54 42.5	1 53 28.8	.. ..	1 29.5	173	2	49
+ 27 00	+62 25.8	+61 20.2	+60 16.6	1 54 45.8	1 53 31.6	1 52 24.0	1 30.0	174	2	49
+ 27 30	+62 40.0	+61 33.7	+60 30.3	1 54 49.1	1 53 35.1	1 52 25.8	1 30.6	174	3	50
+ 28 00	+62 54.1	+61 47.3	+60 43.9	1 54 52.3	1 53 38.6	1 52 27.6	1 31.1	174	3	50
+ 28 30	+63 08.2	+62 00.8	+60 57.5	1 54 55.6	1 53 42.1	1 52 29.3	1 31.6	175	3	51
+ 29 00	+63 22.4	+62 14.4	+61 10.6	1 54 58.8	1 53 45.6	1 52 32.9	1 32.1	175	4	51
+ 29 30	+63 36.3	+62 27.9	+61 23.7	1 55 02.8	1 53 49.1	1 52 36.5	1 32.6	176	4	51
+ 30 00	+63 49.9	+62 41.5	+61 36.7	1 55 07.6	1 53 52.6	1 52 40.1	1 33.1	176	4	52
+ 30 30	+64 03.3	+62 55.0	+61 49.8	1 55 12.7	1 53 56.1	1 52 43.7	1 33.6	177	5	52
+ 31 00	+64 16.6	+63 08.6	+62 02.8	1 55 18.3	1 53 59.6	1 52 47.3	1 34.1	177	5	53
+ 31 30	+64 29.7	+63 21.8	+62 15.9	1 55 24.3	1 54 04.0	1 52 50.9	1 34.6	177	5	53
+ 32 00	+64 42.7	+63 34.8	+62 28.9	1 55 30.7	1 54 09.0	1 52 54.5	1 35.1	178	6	54
+ 32 30	+64 55.6	+63 47.7	+62 42.0	1 55 36.9	1 54 14.3	1 52 58.1	1 35.6	178	6	54
+ 33 00	+65 08.4	+64 00.4	+62 54.9	1 55 43.4	1 54 20.0	1 53 02.1	1 36.1	178	6	55
+ 33 30	+65 21.1	+64 12.9	+63 07.5	1 55 50.2	1 54 26.1	1 53 07.0	1 36.6	179	6	55
+ 34 00	+65 33.7	+64 25.4	+63 19.9	1 55 57.3	1 54 32.4	1 53 12.2	1 37.1	179	7	56
+ 34 30	+65 46.1	+64 37.8	+63 32.3	1 56 04.5	1 54 38.7	1 53 17.7	1 37.5	180	7	56
+ 35 00	+65 58.4	+64 50.0	+63 44.4	1 56 11.9	1 54 45.3	1 53 23.6	1 38.0	180	7	57
+ 35 30	+66 10.5	+65 02.2	+63 56.4	1 56 19.5	1 54 52.1	1 53 29.9	1 38.5	180	8	57
+ 36 00	+66 22.5	+65 14.2	+64 08.4	1 56 27.3	1 54 59.2	1 53 36.1	1 39.0	180	8	58
+ 36 30	+66 34.4	+65 26.0	+64 20.3	1 56 35.3	1 55 06.4	1 53 42.5	1 39.5	181	8	58
+ 37 00	+66 46.2	+65 37.8	+64 32.0	1 56 43.4	1 55 13.8	1 53 49.2	1 39.9	181	9	59
+ 37 30	+66 57.8	+65 49.4	+64 43.6	1 56 51.7	1 55 21.5	1 53 56.2	1 40.4	181	9	59
+ 38 00	+67 09.3	+66 00.9	+64 55.1	1 57 00.2	1 55 29.3	1 54 03.3	1 40.9	182	9	60
+ 38 30	+67 20.6	+66 12.3	+65 06.5	1 57 08.9	1 55 37.3	1 54 10.6	1 41.3	182	9	60
+ 39 00	+67 31.8	+66 23.6	+65 17.8	1 57 17.6	1 55 45.4	1 54 18.1	1 41.8	182	10	61
+ 39 30	+67 42.9	+66 34.7	+65 28.9	1 57 26.6	1 55 53.7	1 54 25.8	1 42.3	183	10	61
+ 40 00	+67 53.8	+66 45.7	+65 39.9	1 57 35.6	1 56 02.2	1 54 33.6	1 42.7	183	10	62
+ 40 30	+68 04.6	+66 56.5	+65 50.8	1 57 44.8	1 56 10.8	1 54 41.6	1 43.2	183	10	62
+ 41 00	+68 15.3	+67 07.2	+66 01.6	1 57 54.2	1 56 19.6	1 54 49.8	1 43.6	183	11	63
+ 41 30	+68 25.8	+67 17.8	+66 12.2	1 58 03.6	1 56 28.5	1 54 58.2	1 44.0	184	11	63
+ 42 00	+68 36.1	+67 28.3	+66 22.7	1 58 13.1	1 56 37.6	1 55 06.7	1 44.5	184	11	64
+ 42 30	+68 46.4	+67 38.6	+66 33.1	1 58 22.8	1 56 46.7	1 55 15.4	1 44.9	184	12	64
+ 43 00	+68 56.5	+67 48.8	+66 43.4	1 58 32.5	1 56 56.0	1 55 24.2	1 45.4	184	12	65
+ 43 30	+69 06.4	+67 58.9	+66 53.6	1 58 42.4	1 57 05.4	1 55 33.1	1 45.8	185	12	65
+ 44 00	+69 16.3	+68 08.8	+67 03.6	1 58 52.3	1 57 14.9	1 55 42.2	1 46.2	185	12	66
+ 44 30	+69 25.9	+68 18.6	+67 13.5	1 59 02.3	1 57 24.6	1 55 51.4	1 46.6	185	13	66
+ 45 00	+69 35.5	+68 28.3	+67 23.2	1 59 12.4	1 57 34.3	1 56 00.7	1 47.1	185	13	67
+ 45 30	+69 44.9	+68 37.8	+67 32.9	1 59 22.5	1 57 44.1	1 56 10.1	1 47.5	185	13	67
+ 46 00	+69 54.2	+68 47.3	+67 42.4	1 59 32.7	1 57 54.0	1 56 19.6	1 47.9	186	13	68
+ 46 30	+70 03.3	+68 56.5	+67 51.8	1 59 43.0	1 58 04.0	1 56 29.3	1 48.3	186	14	68
+ 47 00	+70 12.3	+69 05.7	+68 01.1	1 59 53.4	1 58 14.1	1 56 39.0	1 48.7	186	14	69
+ 47 30	+70 21.2	+69 14.7	+68 10.2	2 00 03.7	1 58 24.2	1 56 48.9	1 49.1	186	14	69
+ 48 00	+70 30.0	+69 23.6	+68 19.2	2 00 14.2	1 58 34.4	1 56 58.8	1 49.5	186	14	70
+ 48 30	+70 38.6	+69 32.4	+68 28.1	2 00 24.7	1 58 44.7	1 57 08.8	1 49.9	187	14	70
+ 49 00	+70 47.0	+69 41.0	+68 36.9	2 00 35.2	1 58 55.0	1 57 18.9	1 50.3	187	15	71

To correct for elevation above sea level, please see table of corrections, page 34.

SURFACE PATH OF THE TOTAL PHASE OVER LAND

Longitude	Latitude of:			Universal Time at:			On Central Line			
	Northern Limit	Central Line	Southern Limit	Northern Limit	Central Line	Southern Limit	Maximum Duration	Path Width	Sun's Alt.	Sun's Az.
° ' "	° ' "	° ' "	° ' "	h m s	h m s	h m s	m s	km	°	°
+ 49 30	+70 55.4	+69 49.6	+68 45.5	2 00 45.8	1 59 05.4	1 57 29.1	1 50.7	187	15	71
+ 50 00	+71 03.6	+69 57.9	+68 54.1	2 00 56.4	1 59 15.9	1 57 39.4	1 51.1	187	15	72
+ 50 30	+71 11.7	+70 06.2	+69 02.5	2 01 07.0	1 59 26.4	1 57 49.7	1 51.4	187	15	72
+ 51 00	+71 19.7	+70 14.4	+69 10.8	2 01 17.7	1 59 37.0	1 58 00.1	1 51.8	187	16	73
+ 51 30	+71 27.5	+70 22.4	+69 19.0	2 01 28.4	1 59 47.6	1 58 10.6	1 52.2	188	16	74
+ 52 00	+71 35.3	+70 30.3	+69 27.0	2 01 39.1	1 59 58.2	1 58 21.1	1 52.6	188	16	74
+ 52 30	+71 42.9	+70 38.1	+69 34.9	2 01 49.8	2 00 08.9	1 58 31.7	1 52.9	188	16	75
+ 53 00	+71 50.4	+70 45.7	+69 42.8	2 02 00.5	2 00 19.6	1 58 42.3	1 53.3	188	16	75
+ 53 30	+71 57.7	+70 53.3	+69 50.5	2 02 11.3	2 00 30.3	1 58 53.0	1 53.6	188	17	76
+ 54 00	+72 05.0	+71 00.7	+69 58.0	2 02 22.1	2 00 41.1	1 59 03.7	1 54.0	188	17	76
+ 54 30	+72 12.1	+71 08.0	+70 05.5	2 02 32.8	2 00 51.9	1 59 14.4	1 54.4	188	17	77
+ 55 00	+72 19.1	+71 15.2	+70 12.9	2 02 43.6	2 01 02.7	1 59 25.2	1 54.7	189	17	77
+ 55 30	+72 26.0	+71 22.3	+70 20.1	2 02 54.4	2 01 13.6	1 59 36.1	1 55.0	189	17	78
+ 56 00	+72 32.8	+71 29.3	+70 27.3	2 03 05.2	2 01 24.4	1 59 47.0	1 55.4	189	18	78
+ 56 30	+72 39.4	+71 36.1	+70 34.3	2 03 16.0	2 01 35.3	1 59 57.9	1 55.7	189	18	79
+ 57 00	+72 46.0	+71 42.9	+70 41.2	2 03 26.8	2 01 46.2	2 00 08.8	1 56.1	189	18	79
+ 57 30	+72 52.4	+71 49.5	+70 48.0	2 03 37.6	2 01 57.1	2 00 19.8	1 56.4	189	18	80
+ 58 00	+72 58.8	+71 56.0	+70 54.7	2 03 48.4	2 02 08.1	2 00 30.8	1 56.7	189	18	81
+ 68 00	+74 44.7	+73 45.6	+72 47.6	2 07 21.8	2 05 46.8	2 04 13.8	2 02.7	191	22	92
+ 68 30	+74 49.0	+73 50.1	+72 52.2	2 07 32.3	2 05 57.6	2 04 25.1	2 03.0	192	22	92
+ 69 00	+74 53.3	+73 54.6	+72 56.8	2 07 42.8	2 06 08.5	2 04 36.3	2 03.3	192	22	93
+ 69 30	+74 57.5	+73 58.9	+73 01.3	2 07 53.2	2 06 19.4	2 04 47.5	2 03.5	192	22	93
+ 70 00	+75 01.6	+74 03.2	+73 05.7	2 08 03.7	2 06 30.2	2 04 58.7	2 03.8	192	22	94
+ 70 30	+75 05.6	+74 07.3	+73 10.1	2 08 14.1	2 06 41.1	2 05 09.9	2 04.1	192	22	94
+ 71 00	+75 09.5	+74 11.4	+73 14.3	2 08 24.5	2 06 51.9	2 05 21.1	2 04.3	192	23	95
+ 71 30	+75 13.4	+74 15.5	+73 18.5	2 08 34.9	2 07 02.7	2 05 32.3	2 04.6	192	23	95
+ 72 00	+75 17.2	+74 19.4	+73 22.6	2 08 45.3	2 07 13.5	2 05 43.5	2 04.8	192	23	96
+ 72 30	+75 20.9	+74 23.3	+73 26.6	2 08 55.7	2 07 24.3	2 05 54.7	2 05.1	192	23	97
+ 73 00	+75 24.5	+74 27.1	+73 30.5	2 09 06.0	2 07 35.1	2 06 05.9	2 05.3	192	23	97
+ 73 30	+75 28.1	+74 30.8	+73 34.3	2 09 16.3	2 07 45.9	2 06 17.1	2 05.6	192	23	98
+ 74 00	+75 31.6	+74 34.4	+73 38.1	2 09 26.6	2 07 56.7	2 06 28.3	2 05.8	192	23	98
+ 74 30	+75 35.0	+74 38.0	+73 41.8	2 09 36.9	2 08 07.5	2 06 39.5	2 06.1	193	24	99
+ 75 00	+75 38.3	+74 41.5	+73 45.4	2 09 47.2	2 08 18.2	2 06 50.7	2 06.3	193	24	99
+ 75 30	+75 41.6	+74 44.9	+73 49.0	2 09 57.5	2 08 29.0	2 07 01.9	2 06.6	193	24	100
+ 76 00	+75 44.8	+74 48.2	+73 52.4	2 10 07.7	2 08 39.7	2 07 13.1	2 06.8	193	24	101
+ 76 30	+75 47.9	+74 51.5	+73 55.8	2 10 18.0	2 08 50.4	2 07 24.3	2 07.1	193	24	101
+ 77 00	+75 51.0	+74 54.7	+73 59.2	2 10 28.2	2 09 01.1	2 07 35.5	2 07.3	193	24	102
+ 77 30	+75 54.0	+74 57.8	+74 02.4	2 10 38.4	2 09 11.8	2 07 46.7	2 07.5	193	24	102
+ 78 00	+75 56.9	+75 00.9	+74 05.6	2 10 48.6	2 09 22.6	2 07 57.9	2 07.8	193	24	103
+ 78 30	+75 59.8	+75 03.9	+74 08.7	2 10 58.8	2 09 33.2	2 08 09.1	2 08.0	193	25	103
+ 79 00	+76 02.6	+75 06.8	+74 11.8	2 11 08.9	2 09 43.9	2 08 20.2	2 08.2	193	25	104
+ 79 30	+76 05.3	+75 09.7	+74 14.7	2 11 19.1	2 09 54.6	2 08 31.4	2 08.5	193	25	104
+ 80 00	+76 08.0	+75 12.5	+74 17.6	2 11 29.2	2 10 05.3	2 08 42.6	2 08.7	193	25	105
+ 80 30	+76 10.6	+75 15.2	+74 20.5	2 11 39.3	2 10 16.0	2 08 53.8	2 08.9	193	25	106
+ 81 00	+76 13.2	+75 17.8	+74 23.2	2 11 49.5	2 10 26.6	2 09 05.0	2 09.1	193	25	106
+ 81 30	+76 15.7	+75 20.4	+74 25.9	2 11 59.6	2 10 37.3	2 09 16.2	2 09.4	193	25	107
+ 82 00	+76 18.1	+75 23.0	+74 28.6	2 12 09.7	2 10 47.9	2 09 27.3	2 09.6	193	25	107
+ 82 30	+76 20.4	+75 25.4	+74 31.1	2 12 19.8	2 10 58.6	2 09 38.5	2 09.8	194	26	108
+ 83 00	+76 22.8	+75 27.9	+74 33.7	2 12 29.9	2 11 09.2	2 09 49.7	2 10.0	194	26	108
+ 83 30	+76 25.0	+75 30.2	+74 36.1	2 12 39.9	2 11 19.9	2 10 00.9	2 10.2	194	26	109

To correct for elevation above sea level, please see table of corrections, page 34.

SURFACE PATH OF THE TOTAL PHASE OVER LAND

Longitude	Latitude of:			Universal Time at:			On Central Line			
	Northern Limit	Central Line	Southern Limit	Northern Limit	Central Line	Southern Limit	Maximum Duration	Path Width	Sun's Alt.	Sun's Az.
° ' "	° ' "	° ' "	° ' "	h m s	h m s	h m s	m s	km	°	°
+ 84 00	+76 27.2	+75 32.5	+74 38.5	2 12 50.0	2 11 30.5	2 10 12.1	2 10.4	194	26	110
+ 84 30	+76 29.3	+75 34.7	+74 40.8	2 13 00.1	2 11 41.2	2 10 23.3	2 10.7	194	26	110
+ 85 00	+76 31.4	+75 36.9	+74 43.0	2 13 10.1	2 11 51.8	2 10 34.5	2 10.9	194	26	111
+ 85 30	+76 33.4	+75 39.0	+74 45.2	2 13 20.2	2 12 02.5	2 10 45.7	2 11.1	194	26	111
+ 86 00	+76 35.3	+75 41.0	+74 47.4	2 13 30.2	2 12 13.1	2 10 56.9	2 11.3	194	26	112
+ 86 30	+76 37.2	+75 43.0	+74 49.4	2 13 40.3	2 12 23.7	2 11 08.2	2 11.5	194	26	112
+ 87 00	+76 39.1	+75 44.9	+74 51.4	2 13 50.3	2 12 34.4	2 11 19.4	2 11.7	194	27	113
+ 87 30	+76 40.9	+75 46.8	+74 53.4	2 14 00.3	2 12 45.0	2 11 30.6	2 11.9	194	27	114
+ 88 00	+76 42.6	+75 48.6	+74 55.2	2 14 10.4	2 12 55.7	2 11 41.9	2 12.1	194	27	114
+ 88 30	+76 44.3	+75 50.4	+74 57.1	2 14 20.4	2 13 06.3	2 11 53.1	2 12.3	194	27	115
+ 89 00	+76 45.9	+75 52.1	+74 58.8	2 14 30.5	2 13 17.0	2 12 04.4	2 12.5	194	27	115
+ 89 30	+76 47.5	+75 53.7	+75 00.5	2 14 40.5	2 13 27.7	2 12 15.7	2 12.7	194	27	116
+ 90 00	+76 49.0	+75 55.3	+75 02.2	2 14 50.5	2 13 38.3	2 12 26.9	2 12.9	194	27	116
+ 90 30	+76 50.4	+75 56.8	+75 03.8	2 15 00.6	2 13 49.0	2 12 38.2	2 13.1	194	27	117
+ 91 00	+76 51.8	+75 58.3	+75 05.3	2 15 10.6	2 13 59.7	2 12 49.5	2 13.3	195	27	117
+ 91 30	+76 53.2	+75 59.7	+75 06.8	2 15 20.7	2 14 10.4	2 13 00.9	2 13.5	195	28	118
+ 92 00	+76 54.5	+76 01.1	+75 08.2	2 15 30.7	2 14 21.1	2 13 12.2	2 13.7	195	28	119
+ 92 30	+76 55.8	+76 02.4	+75 09.5	2 15 40.8	2 14 31.8	2 13 23.6	2 13.9	195	28	119
+ 93 00	+76 57.0	+76 03.6	+75 10.8	2 15 50.8	2 14 42.5	2 13 34.9	2 14.1	195	28	120
+ 93 30	+76 58.1	+76 04.8	+75 12.1	2 16 00.9	2 14 53.2	2 13 46.3	2 14.3	195	28	120
+ 94 00	+76 59.2	+76 06.0	+75 13.3	2 16 11.0	2 15 04.0	2 13 57.7	2 14.5	195	28	121
+ 94 30	+77 00.2	+76 07.0	+75 14.4	2 16 21.1	2 15 14.8	2 14 09.1	2 14.7	195	28	122
+ 95 00	+77 01.2	+76 08.1	+75 15.5	2 16 31.2	2 15 25.5	2 14 20.5	2 14.9	195	28	122
+ 95 30	+77 02.2	+76 09.1	+75 16.5	2 16 41.3	2 15 36.3	2 14 32.0	2 15.0	195	28	123
+ 96 00	+77 03.1	+76 10.0	+75 17.5	2 16 51.4	2 15 47.1	2 14 43.5	2 15.2	195	28	123
+ 96 30	+77 03.9	+76 10.9	+75 18.4	2 17 01.5	2 15 57.9	2 14 55.0	2 15.4	195	29	124
+ 97 00	+77 04.7	+76 11.7	+75 19.2	2 17 11.7	2 16 08.8	2 15 06.5	2 15.6	195	29	124
+ 97 30	+77 05.5	+76 12.5	+75 20.0	2 17 21.8	2 16 19.6	2 15 18.0	2 15.8	195	29	125
+ 98 00	+77 06.2	+76 13.2	+75 20.8	2 17 32.0	2 16 30.5	2 15 29.6	2 16.0	195	29	126
+ 98 30	+77 06.8	+76 13.9	+75 21.5	2 17 42.2	2 16 41.4	2 15 41.2	2 16.2	195	29	126
+ 99 00	+77 07.4	+76 14.5	+75 22.1	2 17 52.4	2 16 52.3	2 15 52.8	2 16.3	195	29	127
+ 99 30	+77 07.9	+76 15.1	+75 22.7	2 18 02.6	2 17 03.2	2 16 04.4	2 16.5	195	29	127
+100 00	+77 08.4	+76 15.6	+75 23.2	2 18 12.9	2 17 14.2	2 16 16.1	2 16.7	195	29	128
+100 30	+77 08.9	+76 16.0	+75 23.7	2 18 23.2	2 17 25.2	2 16 27.8	2 16.9	195	29	128
+101 00	+77 09.3	+76 16.4	+75 24.1	2 18 33.4	2 17 36.2	2 16 39.5	2 17.1	196	29	129
+101 30	+77 09.6	+76 16.8	+75 24.5	2 18 43.8	2 17 47.2	2 16 51.3	2 17.2	196	30	130
+102 00	+77 10.0	+76 17.1	+75 24.8	2 18 54.1	2 17 58.3	2 17 03.1	2 17.4	196	30	130
+102 30	+77 10.2	+76 17.4	+75 25.0	2 19 04.4	2 18 09.4	2 17 14.9	2 17.6	196	30	131
+103 00	+77 10.4	+76 17.6	+75 25.3	2 19 14.8	2 18 20.5	2 17 26.8	2 17.8	196	30	131
+103 30	+77 10.6	+76 17.7	+75 25.4	2 19 25.2	2 18 31.7	2 17 38.7	2 18.0	196	30	132
+104 00	+77 10.7	+76 17.8	+75 25.5	2 19 35.7	2 18 42.9	2 17 50.6	2 18.1	196	30	132
+104 30	+77 10.7	+76 17.9	+75 25.5	2 19 46.1	2 18 54.1	2 18 02.6	2 18.3	196	30	133
+105 00	+77 10.8	+76 17.9	+75 25.5	2 19 56.6	2 19 05.3	2 18 14.6	2 18.5	196	30	134
+105 30	+77 10.7	+76 17.8	+75 25.5	2 20 07.1	2 19 16.6	2 18 26.7	2 18.7	196	30	134
+106 00	+77 10.6	+76 17.7	+75 25.3	2 20 17.7	2 19 28.0	2 18 38.8	2 18.8	196	30	135
+106 30	+77 10.5	+76 17.6	+75 25.2	2 20 28.3	2 19 39.3	2 18 50.9	2 19.0	196	31	135
+107 00	+77 10.3	+76 17.4	+75 24.9	2 20 38.9	2 19 50.7	2 19 03.1	2 19.2	196	31	136
+107 30	+77 10.1	+76 17.1	+75 24.6	2 20 49.5	2 20 02.2	2 19 15.3	2 19.4	196	31	137
+108 00	+77 09.8	+76 16.8	+75 24.3	2 21 00.2	2 20 13.6	2 19 27.6	2 19.5	196	31	137
+108 30	+77 09.5	+76 16.4	+75 23.9	2 21 11.0	2 20 25.2	2 19 40.0	2 19.7	196	31	138

To correct for elevation above sea level, please see table of corrections, page 34.

SURFACE PATH OF THE TOTAL PHASE OVER LAND

Longitude	Latitude of:			Universal Time at:			On Central Line			
	Northern Limit	Central Line	Southern Limit	Northern Limit	Central Line	Southern Limit	Maximum Duration	Path Width	Sun's Alt.	Sun's Az.
° ' "	° ' "	° ' "	° ' "	h m s	h m s	h m s	m s	km	°	°
+109 00	+77 09.1	+76 16.0	+75 23.5	2 21 21.7	2 20 36.7	2 19 52.3	2 19.9	196	31	138
+109 30	+77 08.7	+76 15.6	+75 23.0	2 21 32.5	2 20 48.4	2 20 04.8	2 20.0	196	31	139
+110 00	+77 08.2	+76 15.1	+75 22.4	2 21 43.4	2 21 00.0	2 20 17.2	2 20.2	196	31	140
+110 30	+77 07.7	+76 14.5	+75 21.8	2 21 54.3	2 21 11.7	2 20 29.8	2 20.4	196	31	140
+111 00	+77 07.1	+76 13.9	+75 21.1	2 22 05.2	2 21 23.5	2 20 42.4	2 20.5	196	31	141
+111 30	+77 06.5	+76 13.2	+75 20.4	2 22 16.2	2 21 35.3	2 20 55.0	2 20.7	196	31	141
+112 00	+77 05.8	+76 12.5	+75 19.6	2 22 27.2	2 21 47.2	2 21 07.7	2 20.9	197	32	142
+112 30	+77 05.1	+76 11.7	+75 18.8	2 22 38.3	2 21 59.1	2 21 20.5	2 21.1	197	32	142
+113 00	+77 04.3	+76 10.8	+75 17.9	2 22 49.4	2 22 11.1	2 21 33.3	2 21.2	197	32	143
+113 30	+77 03.4	+76 09.9	+75 16.9	2 23 00.6	2 22 23.1	2 21 46.2	2 21.4	197	32	144
+114 00	+77 02.6	+76 09.0	+75 15.9	2 23 11.8	2 22 35.2	2 21 59.1	2 21.6	197	32	144
+114 30	+77 01.6	+76 08.0	+75 14.9	2 23 23.1	2 22 47.3	2 22 12.2	2 21.7	197	32	145
+115 00	+77 00.7	+76 07.0	+75 13.7	2 23 34.4	2 22 59.5	2 22 25.3	2 21.9	197	32	145
+115 30	+76 59.6	+76 05.8	+75 12.6	2 23 45.8	2 23 11.8	2 22 38.4	2 22.1	197	32	146
+116 00	+76 58.5	+76 04.7	+75 11.3	2 23 57.2	2 23 24.1	2 22 51.6	2 22.2	197	32	147
+116 30	+76 57.4	+76 03.5	+75 10.0	2 24 08.7	2 23 36.5	2 23 05.0	2 22.4	197	32	147
+117 00	+76 56.2	+76 02.2	+75 08.7	2 24 20.3	2 23 49.0	2 23 18.3	2 22.6	197	32	148
+117 30	+76 54.9	+76 00.9	+75 07.2	2 24 31.9	2 24 01.6	2 23 31.8	2 22.7	197	33	148
+118 00	+76 53.6	+75 59.5	+75 05.8	2 24 43.6	2 24 14.2	2 23 45.3	2 22.9	197	33	149
+134 00	+75 40.3	+74 41.4	+73 43.0	2 31 43.8	2 31 48.1	2 31 53.5	2 28.1	199	35	169
+134 30	+75 36.8	+74 37.7	+73 39.1	2 31 58.8	2 32 04.4	2 32 11.0	2 28.2	199	36	170
+135 00	+75 33.3	+74 34.0	+73 35.2	2 32 14.0	2 32 20.8	2 32 28.6	2 28.4	199	36	170
+135 30	+75 29.7	+74 30.2	+73 31.2	2 32 29.3	2 32 37.3	2 32 46.4	2 28.5	199	36	171
+136 00	+75 26.1	+74 26.3	+73 27.1	2 32 44.7	2 32 54.0	2 33 04.4	2 28.7	199	36	171
+136 30	+75 22.3	+74 22.3	+73 22.8	2 33 00.3	2 33 10.9	2 33 22.6	2 28.9	199	36	172
+137 00	+75 18.5	+74 18.2	+73 18.5	2 33 16.1	2 33 28.0	2 33 41.0	2 29.0	199	36	173
+137 30	+75 14.6	+74 14.1	+73 14.1	2 33 32.0	2 33 45.2	2 33 59.6	2 29.2	199	36	173
+138 00	+75 10.6	+74 09.8	+73 09.6	2 33 48.1	2 34 02.7	2 34 18.4	2 29.3	199	36	174
+138 30	+75 06.5	+74 05.5	+73 05.0	2 34 04.4	2 34 20.3	2 34 37.3	2 29.5	199	36	175
+139 00	+75 02.3	+74 01.0	+73 00.3	2 34 20.9	2 34 38.1	2 34 56.5	2 29.6	199	36	175
+139 30	+74 58.0	+73 56.5	+72 55.5	2 34 37.5	2 34 56.1	2 35 15.9	2 29.8	199	36	176
+140 00	+74 53.6	+73 51.9	+72 50.6	2 34 54.3	2 35 14.3	2 35 35.5	2 30.0	200	36	177
+140 30	+74 49.1	+73 47.1	+72 45.6	2 35 11.3	2 35 32.7	2 35 55.3	2 30.1	200	37	177
+141 00	+74 44.6	+73 42.3	+72 40.5	2 35 28.5	2 35 51.3	2 36 15.3	2 30.3	200	37	178
+141 30	+74 39.9	+73 37.3	+72 35.3	2 35 45.9	2 36 10.1	2 36 35.6	2 30.4	200	37	179
+142 00	+74 35.1	+73 32.3	+72 30.0	2 36 03.5	2 36 29.2	2 36 56.1	2 30.6	200	37	179
+142 30	+74 30.3	+73 27.1	+72 24.5	2 36 21.3	2 36 48.4	2 37 16.9	2 30.7	200	37	180
+143 00	+74 25.3	+73 21.8	+72 18.9	2 36 39.4	2 37 07.9	2 37 37.9	2 30.9	200	37	181
+143 30	+74 20.2	+73 16.5	+72 13.3	2 36 57.6	2 37 27.7	2 37 59.1	2 31.0	200	37	181
+144 00	+74 15.0	+73 11.0	+72 07.5	2 37 16.1	2 37 47.6	2 38 20.6	2 31.2	200	37	182
+144 30	+74 09.8	+73 05.3	+72 01.5	2 37 34.8	2 38 07.9	2 38 42.4	2 31.3	200	37	183
+145 00	+74 04.3	+72 59.6	+71 55.5	2 37 53.7	2 38 28.3	2 39 04.4	2 31.5	200	37	184
+145 30	+73 58.8	+72 53.8	+71 49.3	2 38 12.9	2 38 49.1	2 39 26.8	2 31.6	200	37	184
+146 00	+73 53.2	+72 47.8	+71 43.0	2 38 32.3	2 39 10.1	2 39 49.4	2 31.8	200	37	185
+146 30	+73 47.4	+72 41.7	+71 36.6	2 38 51.9	2 39 31.3	2 40 12.3	2 31.9	200	38	186
+147 00	+73 41.5	+72 35.5	+71 30.0	2 39 11.8	2 39 52.9	2 40 35.4	2 32.1	201	38	186
+147 30	+73 35.5	+72 29.1	+71 23.3	2 39 32.0	2 40 14.7	2 40 58.9	2 32.2	201	38	187
+148 00	+73 29.4	+72 22.6	+71 16.5	2 39 52.5	2 40 36.8	2 41 22.7	2 32.4	201	38	188
+148 30	+73 23.2	+72 16.0	+71 09.5	2 40 13.2	2 40 59.2	2 41 46.8	2 32.5	201	38	189
+149 00	+73 16.8	+72 09.3	+71 02.4	2 40 34.2	2 41 21.9	2 42 11.3	2 32.7	201	38	189

To correct for elevation above sea level, please see table of corrections, page 34.

SURFACE PATH OF THE TOTAL PHASE OVER LAND

Longitude	Latitude of:			Universal Time at:			On Central Line		
	Northern Limit	Central Line	Southern Limit	Northern Limit	Central Line	Southern Limit	Maximum Duration	Path Width	Sun's Alt. Az.
° ' "	° ' "	° ' "	° ' "	h m s	h m s	h m s	m s	km	° °
+149 30	+73 10.3	+72 02.4	+70 55.1	2 40 55.5	2 41 45.0	2 42 36.1	2 32.8	201	38 190
+150 00	+73 03.6	+71 55.3	+70 47.7	2 41 17.1	2 42 08.3	2 43 01.2	2 32.9	201	38 191
+150 30	+72 56.8	+71 48.1	+70 40.1	2 41 39.0	2 42 32.0	2 43 26.6	2 33.1	201	38 191
+151 00	+72 49.9	+71 40.8	+70 32.4	2 42 01.3	2 42 56.0	2 43 52.4	2 33.2	201	38 192
+151 30	+72 42.8	+71 33.3	+70 24.5	2 42 23.8	2 43 20.3	2 44 18.6	2 33.4	201	38 193
+152 00	+72 35.6	+71 25.7	+70 16.5	2 42 46.7	2 43 45.0	2 44 45.2	2 33.5	201	38 194
+152 30	+72 28.2	+71 17.9	+70 08.2	2 43 09.9	2 44 10.1	2 45 12.1	2 33.6	201	39 194
+153 00	+72 20.6	+71 09.9	+69 59.9	2 43 33.4	2 44 35.5	2 45 39.4	2 33.8	202	39 195
+153 30	+72 12.9	+71 01.8	+69 51.3	2 43 57.3	2 45 01.3	2 46 07.1	2 33.9	202	39 196
+154 00	+72 05.1	+70 53.5	+69 42.6	2 44 21.6	2 45 27.5	2 46 35.2	2 34.0	202	39 197
+154 30	+71 57.1	+70 45.0	+69 33.7	2 44 46.2	2 45 54.1	2 47 03.8	2 34.1	202	39 197
+155 00	+71 48.9	+70 36.4	+69 24.6	2 45 11.2	2 46 21.0	2 47 32.7	2 34.3	202	39 198
+155 30	+71 40.5	+70 27.6	+69 15.3	2 45 36.6	2 46 48.4	2 48 02.1	2 34.4	202	39 199
+156 00	+71 32.0	+70 18.6	+69 05.9	2 46 02.4	2 47 16.2	2 48 32.0	2 34.5	202	39 200
+156 30	+71 23.3	+70 09.4	+68 56.2	2 46 28.6	2 47 44.5	2 49 02.3	2 34.6	202	39 201
+157 00	+71 14.4	+69 60.0	+68 46.3	2 46 55.2	2 48 13.1	2 49 33.0	2 34.7	202	39 201
+157 30	+71 05.3	+69 50.4	+68 36.3	2 47 22.3	2 48 42.3	2 50 04.3	2 34.8	203	39 202
+158 00	+70 56.0	+69 40.6	+68 26.0	2 47 49.7	2 49 11.9	2 50 36.0	2 34.9	203	39 203
+158 30	+70 46.6	+69 30.7	+68 15.6	2 48 17.7	2 49 41.9	2 51 08.2	2 35.0	203	39 204
+159 00	+70 36.9	+69 20.5	+68 04.9	2 48 46.1	2 50 12.5	2 51 40.9	2 35.1	203	40 205
+159 30	+70 27.0	+69 10.1	+67 54.0	2 49 14.9	2 50 43.5	2 52 14.2	2 35.2	203	40 205
+160 00	+70 16.9	+68 59.5	+67 42.9	2 49 44.3	2 51 15.1	2 52 47.9	2 35.3	203	40 206
+160 30	+70 06.6	+68 48.6	+67 31.5	2 50 14.1	2 51 47.2	2 53 22.2	2 35.4	203	40 207
+161 00	+69 56.1	+68 37.6	+67 19.9	2 50 44.4	2 52 19.7	2 53 57.1	2 35.5	203	40 208
+161 30	+69 45.4	+68 26.3	+67 08.1	2 51 15.3	2 52 52.9	2 54 32.5	2 35.6	204	40 209
+162 00	+69 34.4	+68 14.8	+66 56.1	2 51 46.6	2 53 26.6	2 55 08.5	2 35.6	204	40 209
+162 30	+69 23.3	+68 03.0	+66 43.8	2 52 18.6	2 54 00.8	2 55 45.0	2 35.7	204	40 210
+163 00	+69 11.8	+67 51.0	+66 31.2	2 52 51.0	2 54 35.6	2 56 22.2	2 35.8	204	40 211
+163 30	+69 00.2	+67 38.8	+66 18.4	2 53 24.0	2 55 11.0	2 56 59.9	2 35.8	204	40 212
+164 00	+68 48.2	+67 26.3	+66 05.4	2 53 57.6	2 55 47.0	2 57 38.3	2 35.9	204	40 213
+164 30	+68 36.1	+67 13.6	+65 52.0	2 54 31.8	2 56 23.6	2 58 17.3	2 35.9	204	40 214
+165 00	+68 23.7	+67 00.5	+65 38.4	2 55 06.6	2 57 00.8	2 58 56.9	2 36.0	205	40 215
+165 30	+68 11.0	+66 47.2	+65 24.6	2 55 42.0	2 57 38.7	2 59 37.2	2 36.0	205	40 216
+166 00	+67 58.0	+66 33.7	+65 10.4	2 56 18.0	2 58 17.2	3 00 18.1	2 36.0	205	40 216
+166 30	+67 44.8	+66 19.9	+64 56.0	2 56 54.7	2 58 56.3	3 00 59.7	2 36.0	205	40 217
+167 00	+67 31.3	+66 05.7	+64 41.3	2 57 32.0	2 59 36.1	3 01 41.9	2 36.0	205	40 218
+167 30	+67 17.5	+65 51.3	+64 26.3	2 58 10.0	3 00 16.6	3 02 24.8	2 36.0	205	40 219
+168 00	+67 03.4	+65 36.6	+64 11.1	2 58 48.6	3 00 57.8	3 03 08.5	2 36.0	206	40 220
+168 30	+66 49.1	+65 21.6	+63 55.5	2 59 28.0	3 01 39.6	3 03 52.8	2 36.0	206	40 221
+169 00	+66 34.4	+65 06.4	+63 39.6	3 00 08.0	3 02 22.2	3 04 37.8	2 36.0	206	40 222
+169 30	+66 19.4	+64 50.8	+63 23.4	3 00 48.7	3 03 05.5	3 05 23.5	2 35.9	206	40 223
+170 00	+66 04.1	+64 34.8	+63 06.9	3 01 30.2	3 03 49.5	3 06 10.0	2 35.9	206	40 224
+170 30	+65 48.5	+64 18.6	+62 50.1	3 02 12.4	3 04 34.2	3 06 57.1	2 35.8	206	40 225
+171 00	+65 32.6	+64 02.1	+62 33.0	3 02 55.3	3 05 19.7	3 07 45.0	2 35.7	207	40 226
+171 30	+65 16.4	+63 45.2	+62 15.5	3 03 39.0	3 06 05.9	3 08 33.6	2 35.6	207	40 227
+172 00	+64 59.8	+63 28.0	+61 57.8	3 04 23.4	3 06 52.8	3 09 22.9	2 35.5	207	40 228
+172 30	+64 42.9	+63 10.5	+61 39.7	3 05 08.6	3 07 40.5	3 10 13.0	2 35.4	207	40 229
+173 00	+64 25.7	+62 52.7	+61 21.3	3 05 54.6	3 08 28.9	3 11 03.7	2 35.3	207	40 230
+173 30	+64 08.1	+62 34.5	+61 02.6	3 06 41.3	3 09 18.1	3 11 55.2	2 35.1	208	40 231
+174 00	+63 50.2	+62 16.0	+60 43.5	3 07 28.8	3 10 08.1	3 12 47.4	2 35.0	208	40 232

To correct for elevation above sea level, please see table of corrections, page 34.

SURFACE PATH OF THE TOTAL PHASE OVER LAND

Longitude	Latitude of:			Universal Time at:			On Central Line			
	Northern Limit	Central Line	Southern Limit	Northern Limit	Central Line	Southern Limit	Maximum Duration	Path Width	Sun's Alt.	Sun's Az.
° ' "	° ' "	° ' "	° ' "	h m s	h m s	h m s	m s	km	°	°
+174 30	+63 31.9	+61 57.1	+60 24.1	3 08 17.1	3 10 58.7	3 13 40.3	2 34.8	208	40	233
+175 00	+63 13.3	+61 37.9	+60 04.4	3 09 06.2	3 11 50.2	3 14 33.9	2 34.6	208	40	234
+175 30	+62 54.4	+61 18.4	+59 44.4	3 09 56.0	3 12 42.3	3 15 28.1	2 34.4	209	40	235
+176 00	+62 35.1	+60 58.6	+59 24.1	3 10 46.7	3 13 35.2	3 16 23.1	2 34.1	209	40	236
+176 30	+62 15.4	+60 38.4	+59 03.4	3 11 38.1	3 14 28.8	3 17 18.6	2 33.9	209	40	237
+177 00	+61 55.4	+60 17.8	+58 42.5	3 12 30.3	3 15 23.1	3 18 14.8	2 33.6	209	39	238
-176 00	+56 39.7	+54 58.0	+53 19.8	3 25 51.8	3 29 04.2	3 32 11.1	2 27.6	213	37	252
-175 30	+56 14.9	+54 33.2	+52 55.1	3 26 52.9	3 30 05.8	3 33 12.7	2 27.0	213	36	253
-175 00	+55 49.9	+54 08.3	+52 30.3	3 27 54.3	3 31 07.4	3 34 14.3	2 26.4	213	36	254
-174 30	+55 24.6	+53 43.1	+52 05.3	3 28 56.0	3 32 09.2	3 35 15.8	2 25.7	213	36	255
-174 00	+54 59.2	+53 17.8	+51 40.2	3 29 57.8	3 33 10.9	3 36 17.2	2 25.0	213	35	256
-173 30	+54 33.6	+52 52.4	+51 15.1	3 30 59.8	3 34 12.6	3 37 18.4	2 24.3	213	35	257
-173 00	+54 07.8	+52 26.8	+50 49.8	3 32 01.8	3 35 14.3	3 38 19.3	2 23.6	214	35	258
-172 30	+53 41.8	+52 01.2	+50 24.5	3 33 03.8	3 36 15.7	3 39 19.9	2 22.9	214	34	259
-172 00	+53 15.7	+51 35.4	+49 59.2	3 34 05.7	3 37 16.9	3 40 20.1	2 22.1	214	34	260
-171 30	+52 49.5	+51 09.6	+49 33.9	3 35 07.5	3 38 17.8	3 41 19.9	2 21.3	214	33	261
-171 00	+52 23.3	+50 43.8	+49 08.5	3 36 09.1	3 39 18.4	3 42 19.2	2 20.5	214	33	262
-170 30	+51 56.9	+50 17.9	+48 43.2	3 37 10.4	3 40 18.5	3 43 18.0	2 19.7	214	33	263
-170 00	+51 30.5	+49 52.1	+48 17.9	3 38 11.4	3 41 18.2	3 44 16.2	2 18.9	214	32	264

To correct for elevation above sea level, please see table of corrections, page 34.

PATH OF CENTRAL LINE AT FLYING ALTITUDES

U.T.	10000 Ft.		40000 Ft.		U.T.	10000 Ft.		40000 Ft.	
	Latitude	Longitude	Latitude	Longitude		Latitude	Longitude	Latitude	Longitude
h m	° ' "	° ' "	° ' "	° ' "	h m	° ' "	° ' "	° ' "	° ' "
Limits	+59 45.2	+ 23 45.9	+59 41.0	+ 23 57.3	2 18	+76 15.3	+102 14.0	+76 09.7	+102 41.2
1 54	+63 21.6	+ 31 37.1	+63 50.7	+ 33 07.2	2 19	+76 16.0	+104 54.6	+76 10.2	+105 20.0
1 55	+65 21.7	+ 36 27.0	+65 38.9	+ 37 34.7	2 20	+76 15.2	+107 32.5	+76 09.2	+107 56.1
1 56	+66 47.2	+ 40 12.7	+66 59.5	+ 41 12.1	2 21	+76 13.0	+110 07.5	+76 06.9	+110 29.3
1 57	+67 56.5	+ 43 31.6	+68 05.8	+ 44 26.5	2 22	+76 09.5	+112 39.2	+76 03.2	+112 59.2
1 58	+68 55.5	+ 46 35.9	+69 02.8	+ 47 27.9	2 23	+76 04.8	+115 07.5	+75 58.3	+115 25.6
1 59	+69 47.2	+ 49 31.4	+69 52.9	+ 50 21.6	2 24	+75 58.8	+117 32.0	+75 52.3	+117 48.4
2 00	+70 33.2	+ 52 21.7	+70 37.6	+ 53 10.4	2 25	+75 51.8	+119 52.7	+75 45.2	+120 07.4
2 01	+71 14.6	+ 55 08.7	+71 17.9	+ 55 56.2	2 26	+75 43.7	+122 09.4	+75 37.0	+122 22.5
2 02	+71 52.1	+ 57 53.8	+71 54.5	+ 58 40.4	2 27	+75 34.6	+124 22.1	+75 27.9	+124 33.6
2 03	+72 26.2	+ 60 38.0	+72 27.7	+ 61 23.8	2 28	+75 24.6	+126 30.6	+75 17.9	+126 40.6
2 04	+72 57.2	+ 63 22.1	+72 57.9	+ 64 07.0	2 29	+75 13.7	+128 35.0	+75 07.0	+128 43.6
2 05	+73 25.4	+ 66 06.4	+73 25.4	+ 66 50.6	2 30	+75 02.0	+130 35.3	+74 55.3	+130 42.5
2 06	+73 51.0	+ 68 51.3	+73 50.4	+ 69 34.7	2 31	+74 49.6	+132 31.5	+74 42.8	+132 37.4
2 07	+74 14.1	+ 71 37.0	+74 12.9	+ 72 19.5	2 32	+74 36.4	+134 23.7	+74 29.7	+134 28.4
2 08	+74 35.0	+ 74 23.4	+74 33.2	+ 75 05.0	2 33	+74 22.6	+136 12.0	+74 16.0	+136 15.6
2 09	+74 53.6	+ 77 10.7	+74 51.4	+ 77 51.2	2 34	+74 08.2	+137 56.4	+74 01.6	+137 59.0
2 10	+75 10.2	+ 79 58.6	+75 07.5	+ 80 38.1	2 35	+73 53.3	+139 37.2	+73 46.7	+139 38.7
2 11	+75 24.7	+ 82 47.1	+75 21.5	+ 83 25.3	2 36	+73 37.8	+141 14.3	+73 31.2	+141 14.9
2 12	+75 37.3	+ 85 35.7	+75 33.7	+ 86 12.6	2 37	+73 21.8	+142 47.9	+73 15.3	+142 47.7
2 13	+75 48.0	+ 88 24.3	+75 44.0	+ 88 59.8	2 38	+73 05.4	+144 18.2	+72 59.0	+144 17.2
2 14	+75 56.9	+ 91 12.6	+75 52.5	+ 91 46.6	2 39	+72 48.5	+145 45.2	+72 42.2	+145 43.5
2 15	+76 04.0	+ 94 00.0	+75 59.3	+ 94 32.4	2 40	+72 31.3	+147 09.2	+72 25.0	+147 06.8
2 16	+76 09.4	+ 96 46.4	+76 04.3	+ 97 17.1	2 41	+72 13.7	+148 30.1	+72 07.5	+148 27.1
2 17	+76 13.1	+ 99 31.1	+76 07.8	+100 00.1	2 42	+71 55.8	+149 48.3	+71 49.7	+149 44.7

PATH OF CENTRAL LINE AT FLYING ALTITUDES

U.T.	10000 Ft.		40000 Ft.		U.T.	10000 Ft.		40000 Ft.	
	Latitude	Longitude	Latitude	Longitude		Latitude	Longitude	Latitude	Longitude
h m	° ' "	° ' "	° ' "	° ' "	h m	° ' "	° ' "	° ' "	° ' "
2 43	+71 37.5	+151 03.7	+71 31.5	+150 59.6	3 28	+55 23.0	-176 35.0	+55 20.9	-176 45.8
2 44	+71 19.0	+152 16.5	+71 13.1	+152 11.9	3 29	+54 59.0	-176 05.7	+54 57.0	-176 16.6
2 45	+71 00.2	+153 26.9	+70 54.4	+153 21.8	3 30	+54 34.9	-175 36.4	+54 33.0	-175 47.4
2 46	+70 41.2	+154 34.9	+70 35.4	+154 29.4	3 31	+54 10.6	-175 07.3	+54 08.8	-175 18.3
2 47	+70 21.9	+155 40.7	+70 16.2	+155 34.8	3 32	+53 46.2	-174 38.1	+53 44.5	-174 49.2
2 48	+70 02.4	+156 44.3	+69 56.8	+156 38.1	3 33	+53 21.7	-174 09.0	+53 20.1	-174 20.2
2 49	+69 42.7	+157 45.9	+69 37.2	+157 39.4	3 34	+52 57.0	-173 39.9	+52 55.5	-173 51.1
2 50	+69 22.8	+158 45.6	+69 17.4	+158 38.7	3 35	+52 32.2	-173 10.7	+52 30.8	-173 22.0
2 51	+69 02.8	+159 43.4	+68 57.4	+159 36.3	3 36	+52 07.2	-172 41.5	+52 05.9	-172 52.9
2 52	+68 42.5	+160 39.5	+68 37.3	+160 32.1	3 37	+51 42.1	-172 12.1	+51 40.8	-172 23.6
2 53	+68 22.1	+161 33.9	+68 17.0	+161 26.3	3 38	+51 16.8	-171 42.6	+51 15.6	-171 54.2
2 54	+68 01.6	+162 26.8	+67 56.6	+162 18.9	3 39	+50 51.3	-171 13.0	+50 50.2	-171 24.7
2 55	+67 40.9	+163 18.1	+67 36.0	+163 10.1	3 40	+50 25.6	-170 43.2	+50 24.6	-170 55.0
2 56	+67 20.1	+164 08.0	+67 15.3	+163 59.8	3 41	+49 59.7	-170 13.1	+49 58.8	-170 25.0
2 57	+66 59.2	+164 56.6	+66 54.4	+164 48.2	3 42	+49 33.5	-169 42.8	+49 32.8	-169 54.8
2 58	+66 38.2	+165 43.9	+66 33.5	+165 35.3	3 43	+49 07.2	-169 12.2	+49 06.5	-169 24.3
2 59	+66 17.0	+166 29.9	+66 12.4	+166 21.2	3 44	+48 40.6	-168 41.2	+48 40.0	-168 53.5
3 00	+65 55.7	+167 14.9	+65 51.2	+167 06.0	3 45	+48 13.8	-168 09.9	+48 13.3	-168 22.3
3 01	+65 34.3	+167 58.7	+65 29.9	+167 49.7	3 46	+47 46.7	-167 38.1	+47 46.3	-167 50.7
3 02	+65 12.9	+168 41.4	+65 08.5	+168 32.4	3 47	+47 19.3	-167 05.9	+47 19.0	-167 18.6
3 03	+64 51.3	+169 23.2	+64 47.1	+169 14.0	3 48	+46 51.6	-166 33.1	+46 51.5	-166 46.0
3 04	+64 29.6	+170 04.0	+64 25.5	+169 54.8	3 49	+46 23.5	-165 59.7	+46 23.6	-166 12.8
3 05	+64 07.9	+170 44.0	+64 03.8	+170 34.6	3 50	+45 55.1	-165 25.7	+45 55.3	-165 38.9
3 06	+63 46.0	+171 23.1	+63 42.0	+171 13.6	3 51	+45 26.4	-164 50.9	+45 26.7	-165 04.4
3 07	+63 24.1	+172 01.4	+63 20.2	+171 51.8	3 52	+44 57.2	-164 15.3	+44 57.7	-164 29.1
3 08	+63 02.0	+172 39.0	+62 58.2	+172 29.3	3 53	+44 27.6	-163 38.8	+44 28.2	-163 52.8
3 09	+62 39.9	+173 15.8	+62 36.2	+173 06.1	3 54	+43 57.5	-163 01.4	+43 58.3	-163 15.6
3 10	+62 17.7	+173 52.0	+62 14.1	+173 42.2	3 55	+43 26.9	-162 22.8	+43 27.8	-162 37.4
3 11	+61 55.4	+174 27.5	+61 51.9	+174 17.6	3 56	+42 55.7	-161 42.9	+42 56.8	-161 57.8
3 12	+61 33.1	+175 02.4	+61 29.6	+174 52.5	3 57	+42 23.8	-161 01.7	+42 25.2	-161 17.0
3 13	+61 10.6	+175 36.8	+61 07.3	+175 26.8	3 58	+41 51.3	-160 18.8	+41 52.9	-160 34.6
3 14	+60 48.1	+176 10.6	+60 44.8	+176 00.5	3 59	+41 17.9	-159 34.2	+41 19.8	-159 50.4
3 15	+60 25.5	+176 43.9	+60 22.3	+176 33.8	4 00	+40 43.7	-158 47.5	+40 45.8	-159 04.3
3 16	+60 02.8	+177 16.8	+59 59.7	+177 06.6	4 01	+40 08.5	-157 58.4	+40 10.9	-158 15.8
3 17	+59 40.0	+177 49.2	+59 37.0	+177 39.0	4 02	+39 32.1	-157 06.6	+39 34.8	-157 24.7
3 18	+59 17.1	+178 21.2	+59 14.2	+178 10.9	4 03	+38 54.3	-156 11.5	+38 57.5	-156 30.4
3 19	+58 54.1	+178 52.9	+58 51.3	+178 42.5	4 04	+38 15.0	-155 12.4	+38 18.6	-155 32.4
3 20	+58 31.1	+179 24.1	+58 28.3	+179 13.7	4 05	+37 33.6	-154 08.5	+37 37.8	-154 29.8
3 21	+58 07.9	+179 55.1	+58 05.2	+179 44.7	4 06	+36 49.8	-152 58.5	+36 54.6	-153 21.4
3 22	+57 44.7	-179 34.2	+57 42.1	-179 44.7	4 07	+36 02.8	-151 40.5	+36 08.5	-152 05.5
3 23	+57 21.3	-179 03.8	+57 18.8	-179 14.4	4 08	+35 11.4	-150 11.3	+35 18.4	-150 39.4
3 24	+56 57.9	-178 33.7	+56 55.4	-178 44.3	4 09	+34 13.3	-148 25.1	+34 22.2	-148 58.0
3 25	+56 34.3	-178 03.8	+56 32.0	-178 14.4	4 10	+33 03.3	-146 08.3	+33 15.9	-146 50.6
3 26	+56 10.7	-177 34.0	+56 08.4	-177 44.7	4 11	+31 19.2	-142 22.7	+31 45.5	-143 40.5
3 27	+55 46.9	-177 04.4	+55 44.7	-177 15.2	Limits	+29 54.7	-138 54.6	+29 49.4	-139 00.8

CORRECTIONS TO U.T. AND LATITUDE
FOR ELEVATIONS ABOVE SEA LEVEL

Longitude	Latitude Corr.	U.T. Corr.	Longitude	Latitude Corr.	U.T. Corr.	Longitude	Latitude Corr.	U.T. Corr.
° ' "	"	s	° ' "	"	s	° ' "	"	s
+ 30 00	-18.051	-0.576	+ 55 00	-15.821	-0.577	+ 89 30	-12.064	-0.419
+ 30 30	-18.851	-0.541	+ 55 30	-15.743	-0.576	+ 90 00	-12.036	-0.416
+ 31 00	-19.650	-0.506	+ 56 00	-15.666	-0.574	+ 90 30	-12.008	-0.413
+ 31 30	-19.920	-0.495	+ 56 30	-15.588	-0.573	+ 91 00	-11.982	-0.410
+ 32 00	-19.916	-0.497	+ 57 00	-15.512	-0.572	+ 91 30	-11.956	-0.407
+ 32 30	-19.695	-0.507	+ 57 30	-15.436	-0.570	+ 92 00	-11.931	-0.404
+ 33 00	-19.238	-0.528	+ 58 00	-15.360	-0.569	+ 92 30	-11.906	-0.401
+ 33 30	-18.950	-0.542	+ 68 00	-13.983	-0.532	+ 93 00	-11.882	-0.398
+ 34 00	-18.797	-0.550	+ 68 30	-13.922	-0.529	+ 93 30	-11.859	-0.395
+ 34 30	-18.763	-0.552	+ 69 00	-13.862	-0.527	+ 94 00	-11.837	-0.392
+ 35 00	-18.738	-0.553	+ 69 30	-13.802	-0.525	+ 94 30	-11.815	-0.389
+ 35 30	-18.716	-0.555	+ 70 00	-13.744	-0.523	+ 95 00	-11.794	-0.385
+ 36 00	-18.625	-0.559	+ 70 30	-13.686	-0.520	+ 95 30	-11.774	-0.382
+ 36 30	-18.567	-0.561	+ 71 00	-13.628	-0.518	+ 96 00	-11.754	-0.379
+ 37 00	-18.517	-0.563	+ 71 30	-13.572	-0.516	+ 96 30	-11.735	-0.376
+ 37 30	-18.467	-0.565	+ 72 00	-13.516	-0.513	+ 97 00	-11.717	-0.373
+ 38 00	-18.393	-0.567	+ 72 30	-13.462	-0.511	+ 97 30	-11.699	-0.370
+ 38 30	-18.330	-0.569	+ 73 00	-13.408	-0.508	+ 98 00	-11.682	-0.367
+ 39 00	-18.270	-0.571	+ 73 30	-13.355	-0.506	+ 98 30	-11.666	-0.364
+ 39 30	-18.207	-0.572	+ 74 00	-13.302	-0.503	+ 99 00	-11.650	-0.361
+ 40 00	-18.133	-0.574	+ 74 30	-13.251	-0.501	+ 99 30	-11.635	-0.357
+ 40 30	-18.066	-0.576	+ 75 00	-13.200	-0.498	+100 00	-11.621	-0.354
+ 41 00	-17.999	-0.577	+ 75 30	-13.150	-0.496	+100 30	-11.607	-0.351
+ 41 30	-17.926	-0.578	+ 76 00	-13.101	-0.493	+101 00	-11.594	-0.348
+ 42 00	-17.854	-0.579	+ 76 30	-13.052	-0.491	+101 30	-11.582	-0.345
+ 42 30	-17.782	-0.580	+ 77 00	-13.005	-0.488	+102 00	-11.570	-0.341
+ 43 00	-17.708	-0.581	+ 77 30	-12.958	-0.485	+102 30	-11.559	-0.338
+ 43 30	-17.632	-0.582	+ 78 00	-12.912	-0.483	+103 00	-11.549	-0.335
+ 44 00	-17.558	-0.583	+ 78 30	-12.866	-0.480	+103 30	-11.540	-0.332
+ 44 30	-17.482	-0.583	+ 79 00	-12.822	-0.477	+104 00	-11.531	-0.328
+ 45 00	-17.404	-0.584	+ 79 30	-12.778	-0.475	+104 30	-11.522	-0.325
+ 45 30	-17.327	-0.584	+ 80 00	-12.735	-0.472	+105 00	-11.514	-0.322
+ 46 00	-17.250	-0.585	+ 80 30	-12.693	-0.469	+105 30	-11.507	-0.318
+ 46 30	-17.171	-0.585	+ 81 00	-12.652	-0.467	+106 00	-11.501	-0.315
+ 47 00	-17.092	-0.585	+ 81 30	-12.611	-0.464	+106 30	-11.495	-0.311
+ 47 30	-17.014	-0.585	+ 82 00	-12.571	-0.461	+107 00	-11.490	-0.308
+ 48 00	-16.933	-0.585	+ 82 30	-12.532	-0.458	+107 30	-11.486	-0.305
+ 48 30	-16.854	-0.585	+ 83 00	-12.494	-0.456	+108 00	-11.482	-0.301
+ 49 00	-16.775	-0.585	+ 83 30	-12.457	-0.453	+108 30	-11.479	-0.298
+ 49 30	-16.694	-0.585	+ 84 00	-12.420	-0.450	+109 00	-11.477	-0.294
+ 50 00	-16.615	-0.584	+ 84 30	-12.384	-0.447	+109 30	-11.475	-0.291
+ 50 30	-16.535	-0.584	+ 85 00	-12.348	-0.444	+110 00	-11.474	-0.287
+ 51 00	-16.454	-0.583	+ 85 30	-12.314	-0.442	+110 30	-11.473	-0.284
+ 51 30	-16.375	-0.583	+ 86 00	-12.280	-0.439	+111 00	-11.474	-0.280
+ 52 00	-16.295	-0.582	+ 86 30	-12.247	-0.436	+111 30	-11.475	-0.277
+ 52 30	-16.215	-0.581	+ 87 00	-12.215	-0.433	+112 00	-11.476	-0.273
+ 53 00	-16.136	-0.581	+ 87 30	-12.183	-0.430	+112 30	-11.478	-0.270
+ 53 30	-16.056	-0.580	+ 88 00	-12.152	-0.427	+113 00	-11.481	-0.266
+ 54 00	-15.978	-0.579	+ 88 30	-12.122	-0.424	+113 30	-11.485	-0.262
+ 54 30	-15.899	-0.578	+ 89 00	-12.092	-0.421	+114 00	-11.489	-0.259

Corrections are per thousand feet.

CORRECTIONS TO U.T. AND LATITUDE
FOR ELEVATIONS ABOVE SEA LEVEL

Longitude	Latitude Corr.	U.T. Corr.	Longitude	Latitude Corr.	U.T. Corr.	Longitude	Latitude Corr.	U.T. Corr.
° ' "	"	s	° ' "	"	s	° ' "	"	s
+114 30	-11.494	-0.255	+155 00	-14.762	+0.172	-173 30	-22.268	+0.775
+115 00	-11.500	-0.251	+155 30	-14.852	+0.180	-173 00	-22.299	+0.779
+115 30	-11.506	-0.248	+156 00	-14.944	+0.188	-172 30	-22.322	+0.783
+116 00	-11.513	-0.244	+156 30	-15.037	+0.196	-172 00	-22.335	+0.785
+116 30	-11.520	-0.240	+157 00	-15.133	+0.205	-171 30	-22.340	+0.788
+117 00	-11.529	-0.236	+157 30	-15.230	+0.213	-171 00	-22.335	+0.789
+117 30	-11.538	-0.233	+158 00	-15.329	+0.222	-170 30	-22.322	+0.790
+118 00	-11.548	-0.229	+158 30	-15.430	+0.230	-170 00	-22.300	+0.791
+134 00	-12.258	-0.090	+159 00	-15.533	+0.239			
+134 30	-12.294	-0.085	+159 30	-15.638	+0.248			
+135 00	-12.331	-0.080	+160 00	-15.744	+0.257			
+135 30	-12.369	-0.075	+160 30	-15.853	+0.266			
+136 00	-12.408	-0.070	+161 00	-15.963	+0.275			
+136 30	-12.448	-0.065	+161 30	-16.076	+0.285			
+137 00	-12.489	-0.060	+162 00	-16.190	+0.294			
+137 30	-12.531	-0.055	+162 30	-16.307	+0.304			
+138 00	-12.574	-0.049	+163 00	-16.425	+0.313			
+138 30	-12.618	-0.044	+163 30	-16.545	+0.323			
+139 00	-12.663	-0.039	+164 00	-16.668	+0.333			
+139 30	-12.709	-0.033	+164 30	-16.792	+0.343			
+140 00	-12.756	-0.028	+165 00	-16.918	+0.353			
+140 30	-12.804	-0.022	+165 30	-17.046	+0.364			
+141 00	-12.853	-0.016	+166 00	-17.176	+0.374			
+141 30	-12.904	-0.011	+166 30	-17.308	+0.385			
+142 00	-12.955	-0.005	+167 00	-17.442	+0.395			
+142 30	-13.008	+0.001	+167 30	-17.577	+0.406			
+143 00	-13.062	+0.007	+168 00	-17.714	+0.417			
+143 30	-13.117	+0.013	+168 30	-17.853	+0.428			
+144 00	-13.173	+0.019	+169 00	-17.994	+0.439			
+144 30	-13.231	+0.025	+169 30	-18.136	+0.450			
+145 00	-13.290	+0.031	+170 00	-18.279	+0.461			
+145 30	-13.350	+0.037	+170 30	-18.423	+0.472			
+146 00	-13.411	+0.044	+171 00	-18.569	+0.483			
+146 30	-13.474	+0.050	+171 30	-18.716	+0.495			
+147 00	-13.538	+0.057	+172 00	-18.864	+0.506			
+147 30	-13.603	+0.063	+172 30	-19.012	+0.517			
+148 00	-13.670	+0.070	+173 00	-19.161	+0.529			
+148 30	-13.738	+0.077	+173 30	-19.310	+0.540			
+149 00	-13.808	+0.083	+174 00	-19.460	+0.552			
+149 30	-13.879	+0.090	+174 30	-19.609	+0.563			
+150 00	-13.951	+0.097	+175 00	-19.758	+0.575			
+150 30	-14.025	+0.104	+175 30	-19.906	+0.586			
+151 00	-14.101	+0.111	+176 00	-20.053	+0.597			
+151 30	-14.178	+0.119	+176 30	-20.199	+0.608			
+152 00	-14.256	+0.126	+177 00	-20.344	+0.619			
+152 30	-14.336	+0.133	-176 00	-21.983	+0.748			
+153 00	-14.418	+0.141	-175 30	-22.056	+0.755			
+153 30	-14.502	+0.148	-175 00	-22.121	+0.761			
+154 00	-14.587	+0.156	-174 30	-22.178	+0.766			
+154 30	-14.673	+0.164	-174 00	-22.227	+0.771			

These corrections to latitude and time are to be applied to the corresponding surface data on page 27 to correct for elevation. The units are seconds of arc or seconds of time per thousand feet.

Example

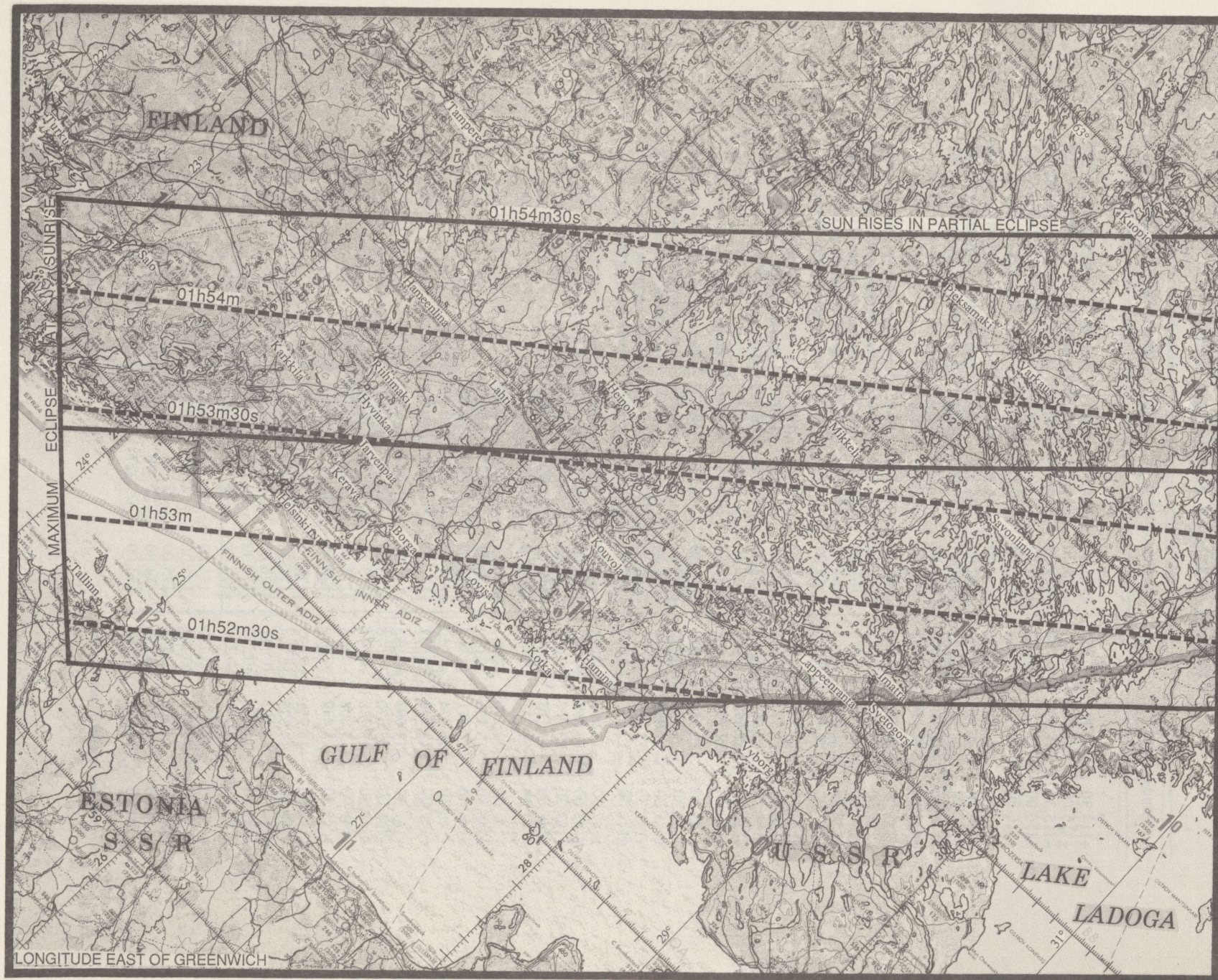
Elevation 1500 ft. at longitude +40°.

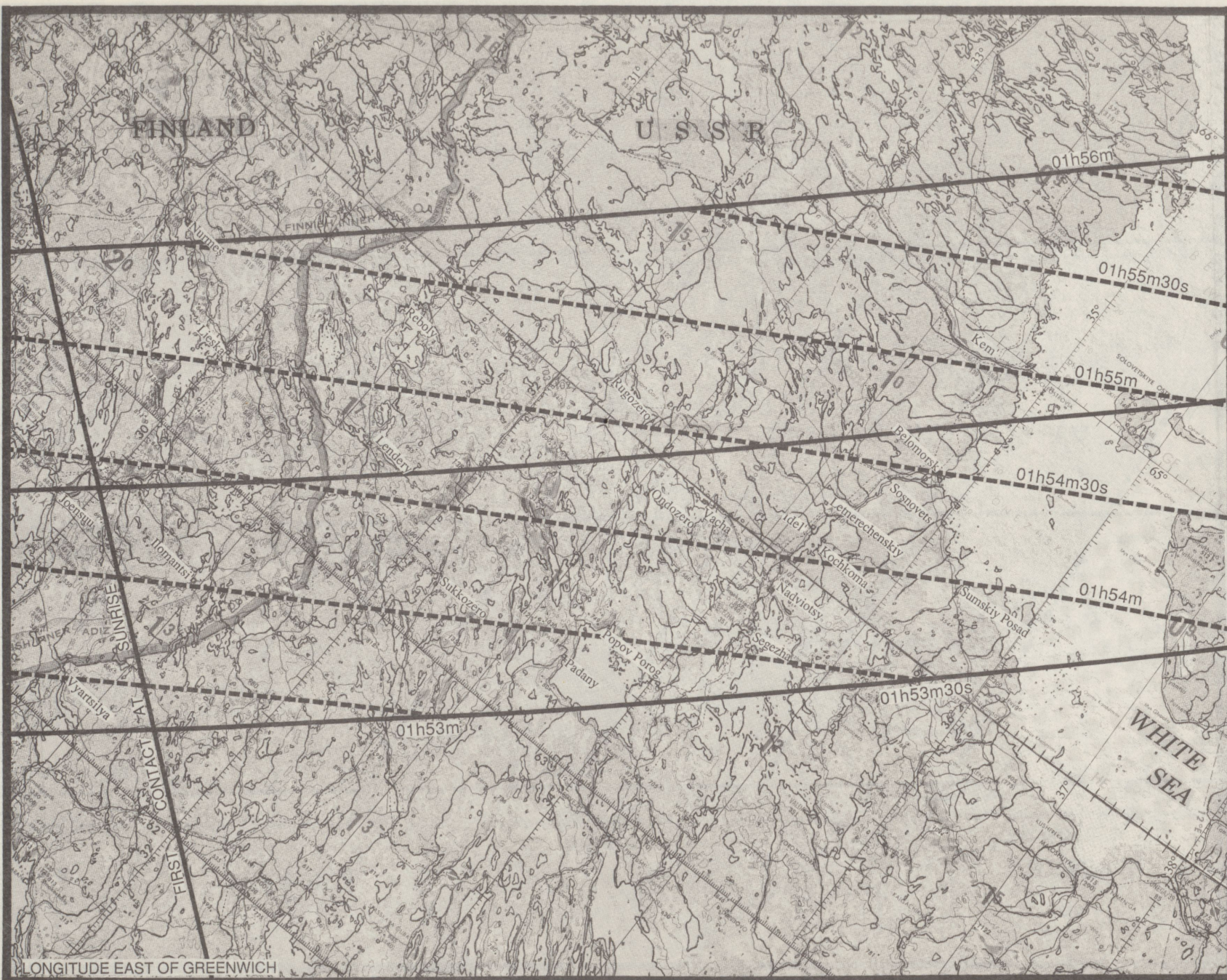
Lat. corr.: $-18''.133 \times 1.5 = -27''.2$
 $= -0''.5$

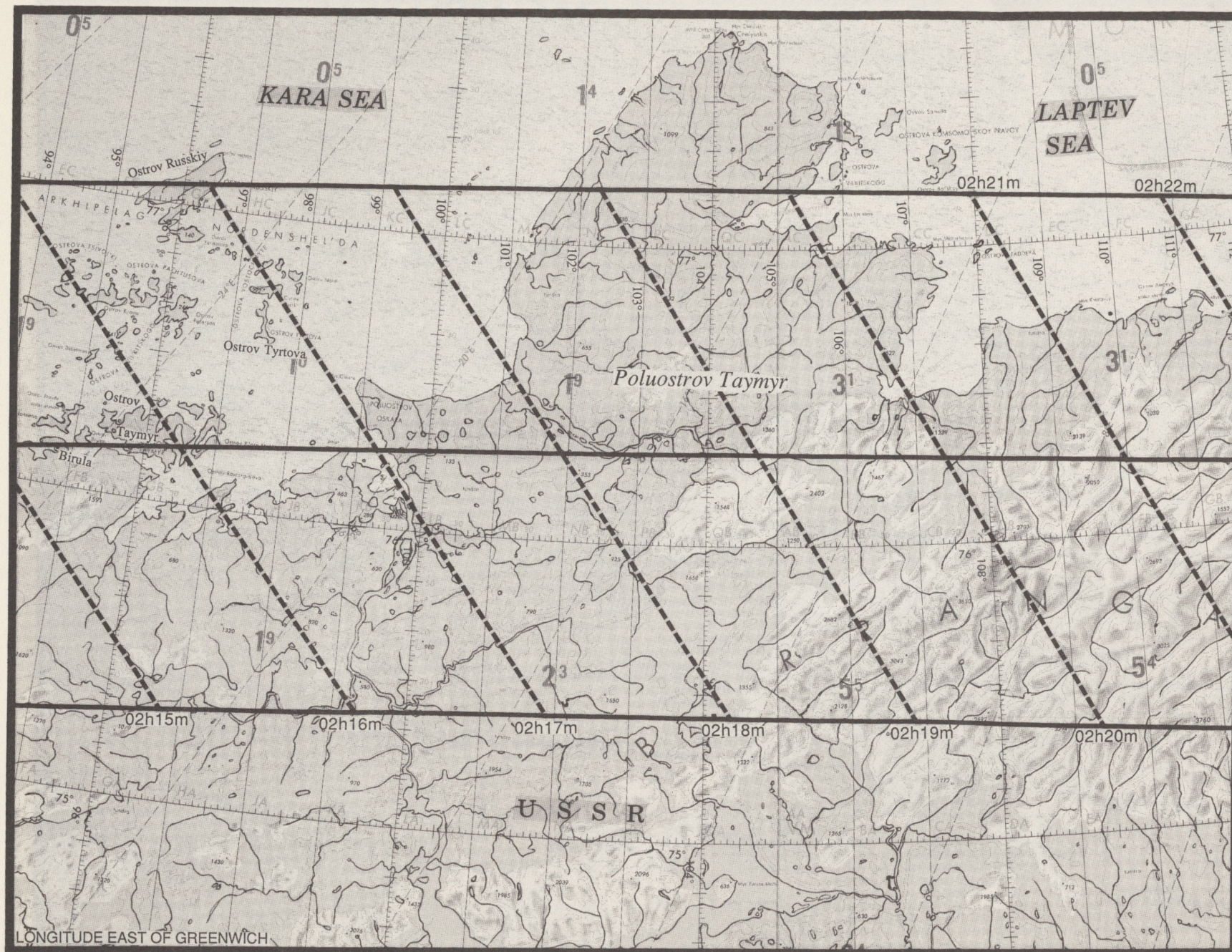
Time corr.: $-0''.574 \times 1.5 = -0''.9$

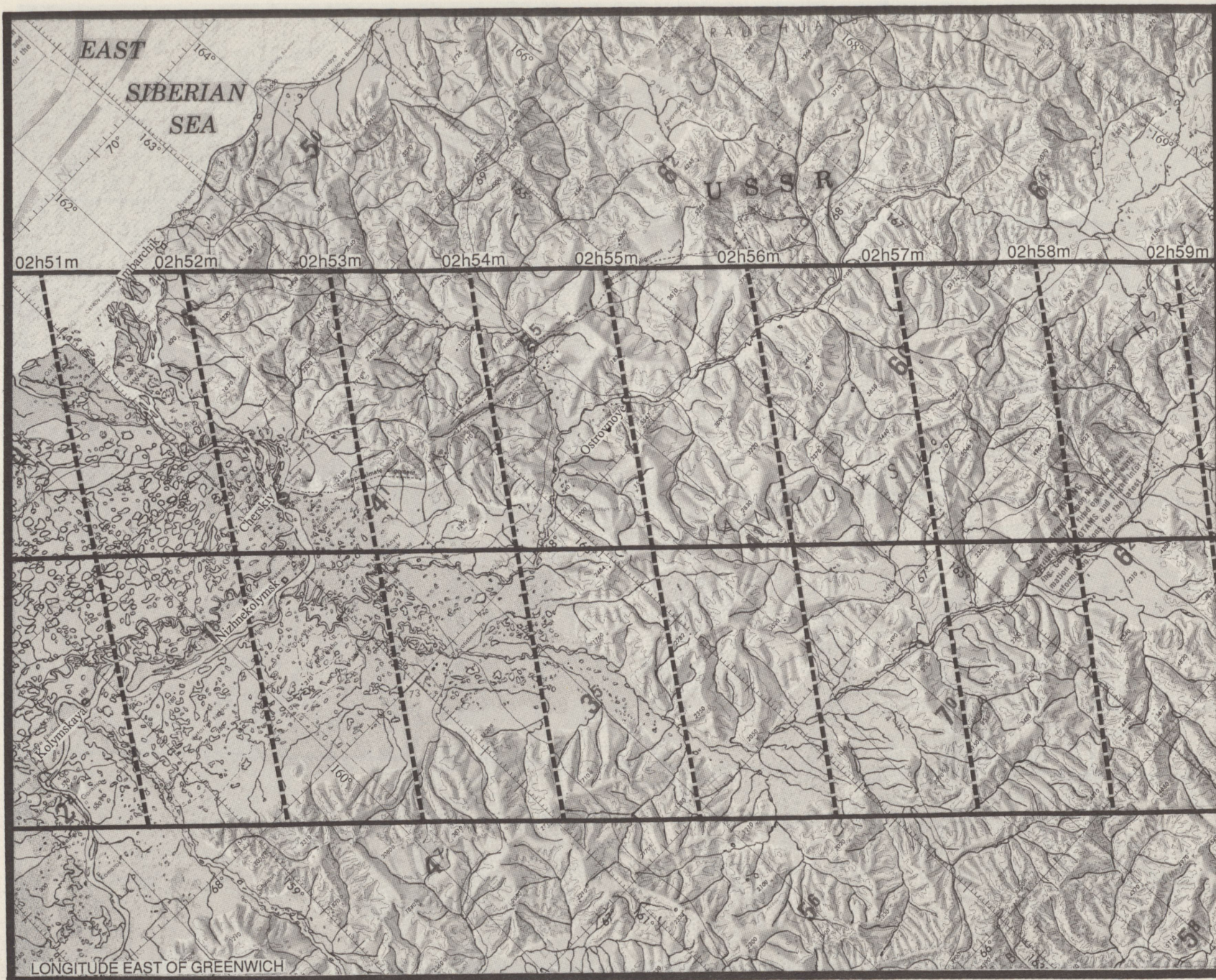
Hence, for the longitude +40° tabular entry on page 27, the three latitude values should be shifted south by 0''.5, and the three times advanced (made earlier) by 0''.9.

Corrections are per thousand feet.

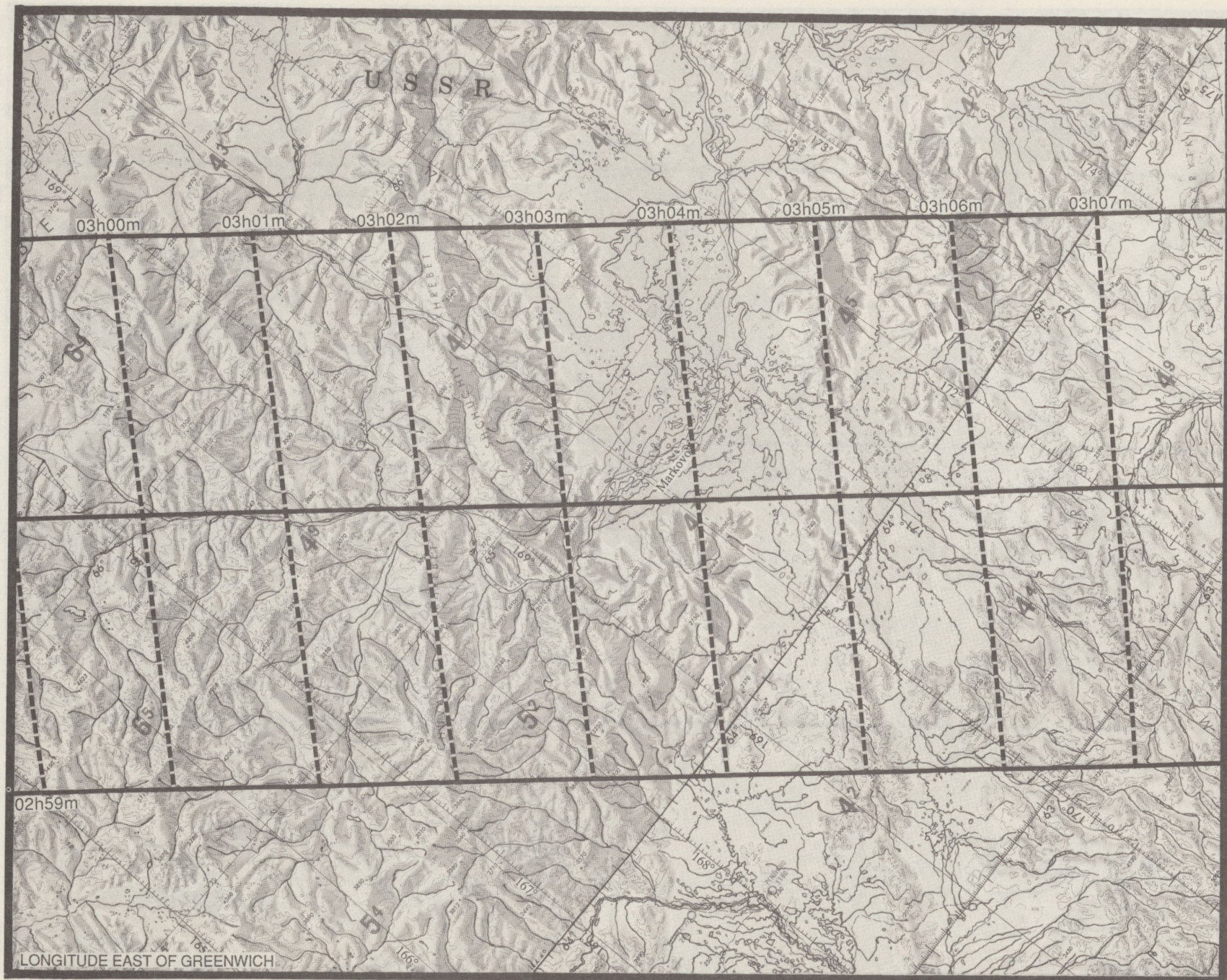






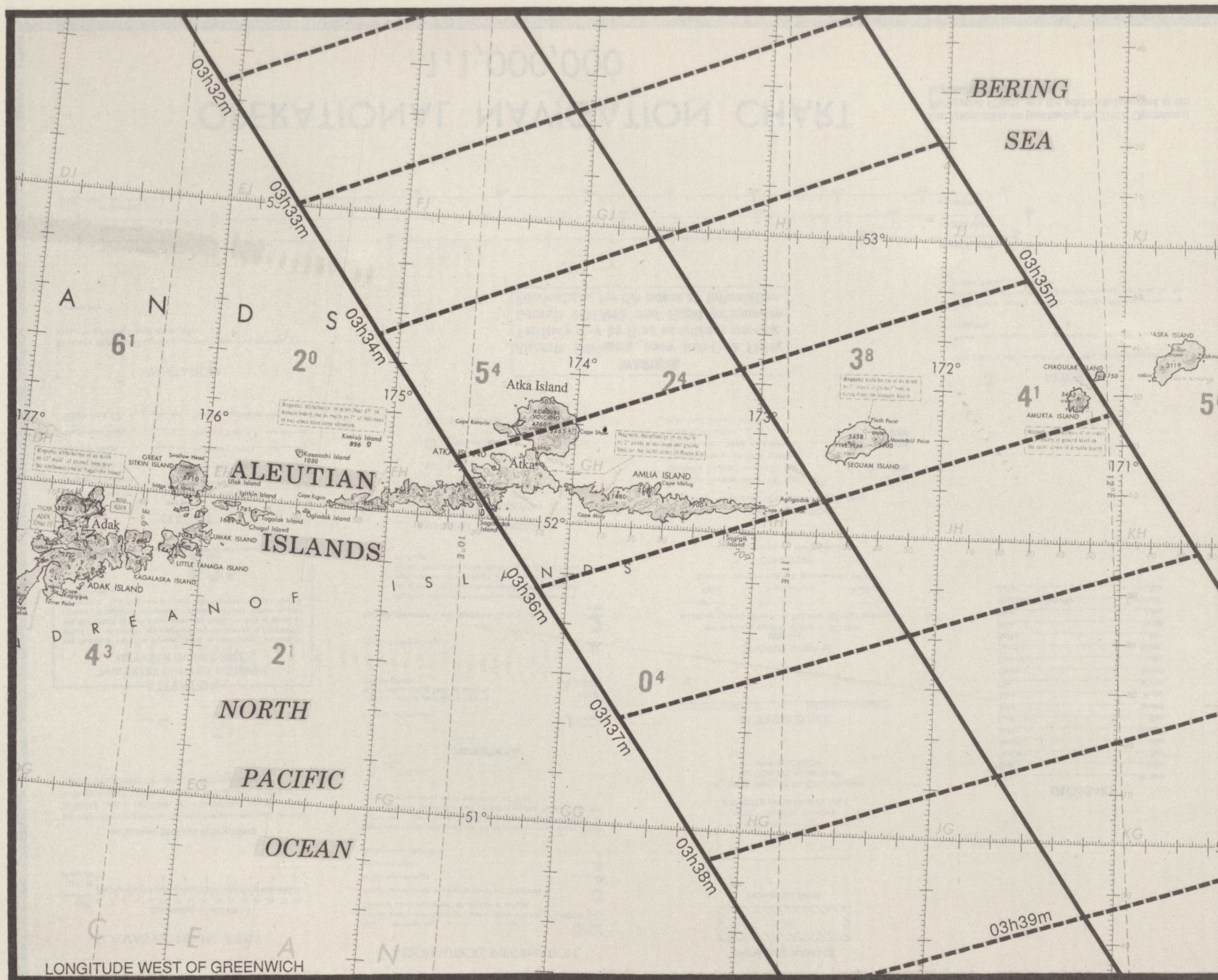


TOTAL SOLAR ECLIPSE OF 22 JULY 1990

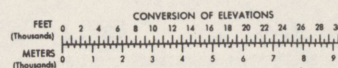


TOTAL SOLAR ECLIPSE OF 22 JULY 1990

41



ELEVATIONS IN FEET



MAXIMUM TERRAIN ELEVATIONS

Maximum Terrain elevation figures centered in the area bounded by ticked lines of LATITUDE and LONGITUDE, are represented in THOUSANDS and HUNDREDS of feet, BUT DO NOT INCLUDE ELEVATIONS OF VERTICAL OBSTRUCTIONS.

3100 feet. 31

ATTENTION
THIS CHART CONTAINS MAXIMUM
ELEVATION FIGURES (MEF)

The Maximum Elevation Figures shown in quadrangles bounded by ticked lines of latitude and longitude are represented in THOUSANDS and HUNDREDS of feet above mean sea level. The MEF is based on information available concerning the highest known feature in each quadrangle, including terrain and obstructions (trees, towers, antennas, etc.)

Example: 12,500 feet. 12⁵

CULTURE

Actual city outline..... Towns and villages (outline unknown)..... □

Land mark features (unillustrated)..... branch Dual lane roads.....

Primary roads..... Secondary roads.....

Tracks and trails..... Multiple track R.R.

Single track R.R. Power transmission line

VEGETATION

To assure legibility of significant relief, vegetation patterns are shown in relatively level areas only.

Vegetation

AERONAUTICAL INFORMATION

Major aerodromes..... EDNA 920
Runway pattern and 6000 foot diameter circle is shown at 1:500,000 scale. Center of circle represents true position of airfield.

Major aerodromes, runway pattern not available.....

Minor aerodromes.....

Seaplane base.....

Jet facilities available..... J

Major aerodromes portrayed have a hard surface runway length of 3000 feet or more. When runway pattern is not shown, number following the name indicates length of longest runway to nearest hundreds of feet. Aerodrome elevations are in feet above sea level.

OBSTRUCTIONS

Vertical obstructions..... 1850 (1250)

Highest vertical obstruction (above MSL) within ticked lines of latitude and longitude..... 1850 (1250)

Multiple obstructions..... 920 (230)

Vertical obstructions with landmark significance.....

Numbers adjacent to obstruction indicate elevation of top of obstruction above mean sea level (MSL). Numerals in parentheses indicate height above ground level (AGL). Vertical obstructions under 200 feet in height (AGL) are not shown.

RADIO AIDS TO NAVIGATION

VHF OMNI RANGE (VOR)

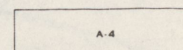
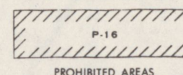
VORTAC

TACAN

VOR with DME

Other facilities

SPECIAL USE AIRSPACE



ALERT, CAUTION, DANGER
RESTRICTED OR WARNING AREA

NUMBERS INDICATE INTERNATIONALLY
RECOGNIZED NUMERICAL
IDENTIFICATION

BUFFER ZONE



CONTOUR INTERVAL

1000 feet
Intermediate contour shown at 500 feet
Auxiliary Contour shown at 250 and 750 foot intervals

Basic Intermediate Auxiliary

Dashed contours indicate approximate relief

CONTOURS

(Accuracy based on Mean Sea Level)
Accurate to within 500 feet.

SPOT ELEVATIONS

(Accuracy based on Mean Sea Level)

Maximum Vertical error 100 feet..... 0000
Maximum Vertical error 400 feet..... x0000
Approximate or doubtful location,
Vertical error same as contours..... 0000
Critical elevation..... 0000
Lake and Stream elevation.....

GLOSSARY

Älv.....Stream
Ezers.....Lake
Guba.....Bay
Järv(i).....Lake
Joki.....Stream
Lahti.....Bay
Maa.....Island
Mys.....Point
Ön.....Island
Ostrov.....Island
Ozero.....Lake
Saari(i).....Island
Selkä.....Bay
Väin.....Strait
Vesi.....Lake
Vodokhranilishche.....Reservoir
Zaliv.....Bay

NOTES

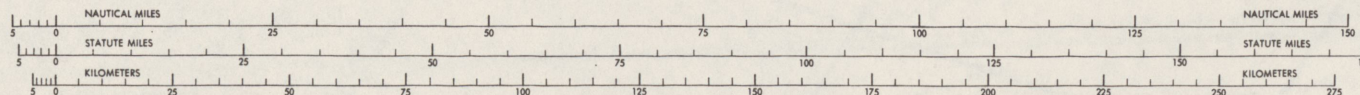
This chart is not an authority for international boundaries.

Power transmission line information on this chart is incomplete.

Geographic names or their spellings do not necessarily reflect recognition of the political status of an area by the United States Government.

WARNING

Aircraft infringing upon Non-Free Flying
Territory may be fired on without warning.
Consult NOTAMS and Flight Information
Publications for the latest air information.



OPERATIONAL NAVIGATION CHART

1:1,000,000

For information on purchasing the DMA Operational Navigation Charts, see the acknowledgements at the beginning of this Circular.

